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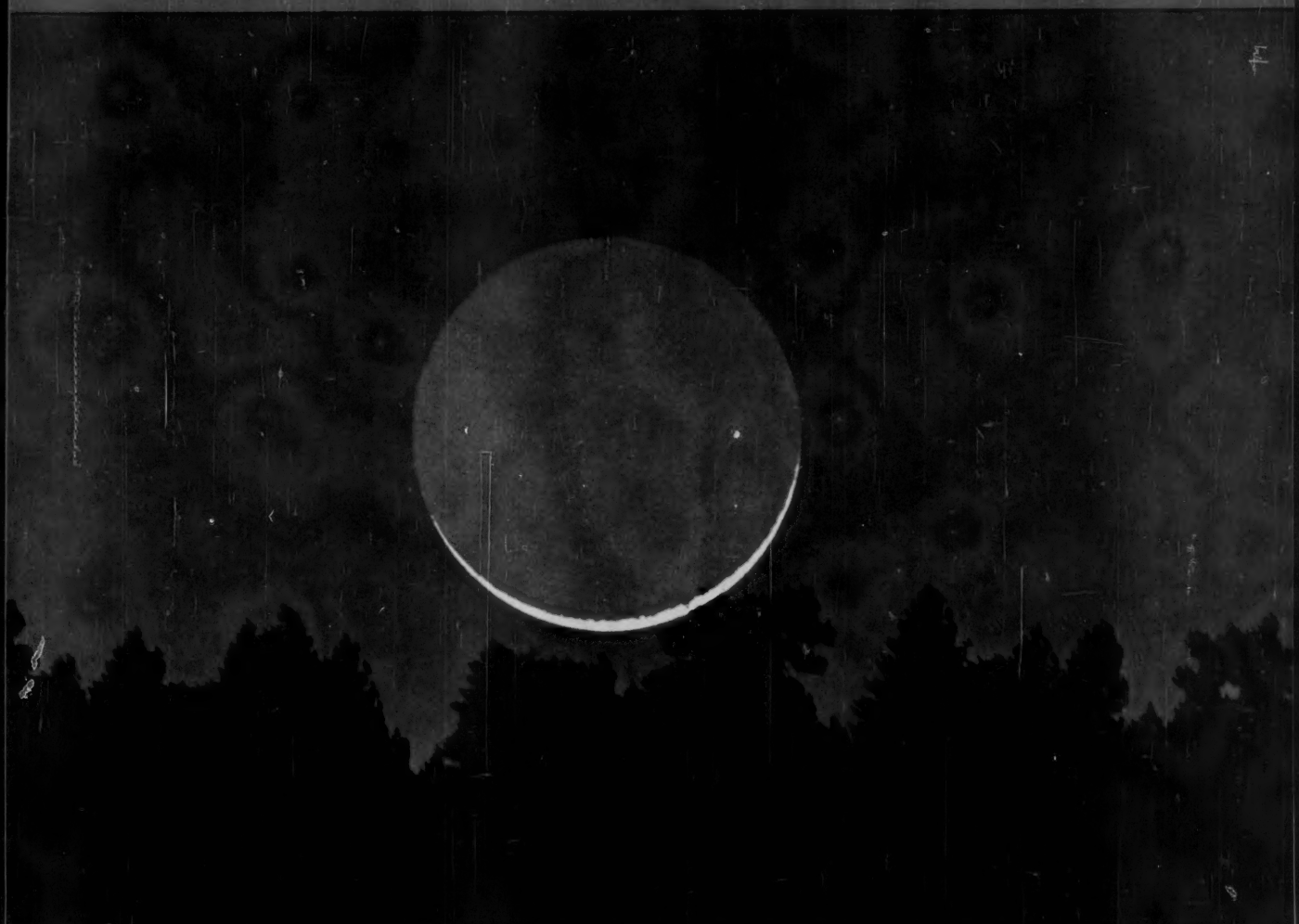

Crescent moon, 29 hours old

★

Vol. XXI, No. 3

MARCH, 1961

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Intense Magnetic Field

Charting the Hidden Side of the Moon

Fast-Moving Disturbances on the Sun

Runaway Stars

American Astronomers Report

Northern and Southern Star Charts

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Sky and TELESCOPE

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Vol. XXI, No. 3 MARCH, 1961

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COVER: On the evening of January 17, 1961, Alan McClure of Los Angeles, California, was preparing to photograph Comets Encke and Candy from Mt. Pinos. He noticed the young crescent moon about to set behind trees a mile away, and at about 6:20 p.m. Pacific standard time took this telephoto picture with his 7-inch f/7 Fecker triplet. The exposure was about 1½ seconds on a blue-sensitive plate. For the comet pictures, see page 157.

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Intense Magnetic Field

A FAINT STAR in the constellation Lacerta has the strongest magnetic field known in nature, according to recent observations by Horace W. Babcock at Mount Wilson and Palomar Observatories. His discovery was made with high-dispersion polarized-light spectrograms taken with the 200-inch telescope. These show a pronounced Zeeman effect — a splitting of spectrum lines that occurs when light originates in a magnetic field.

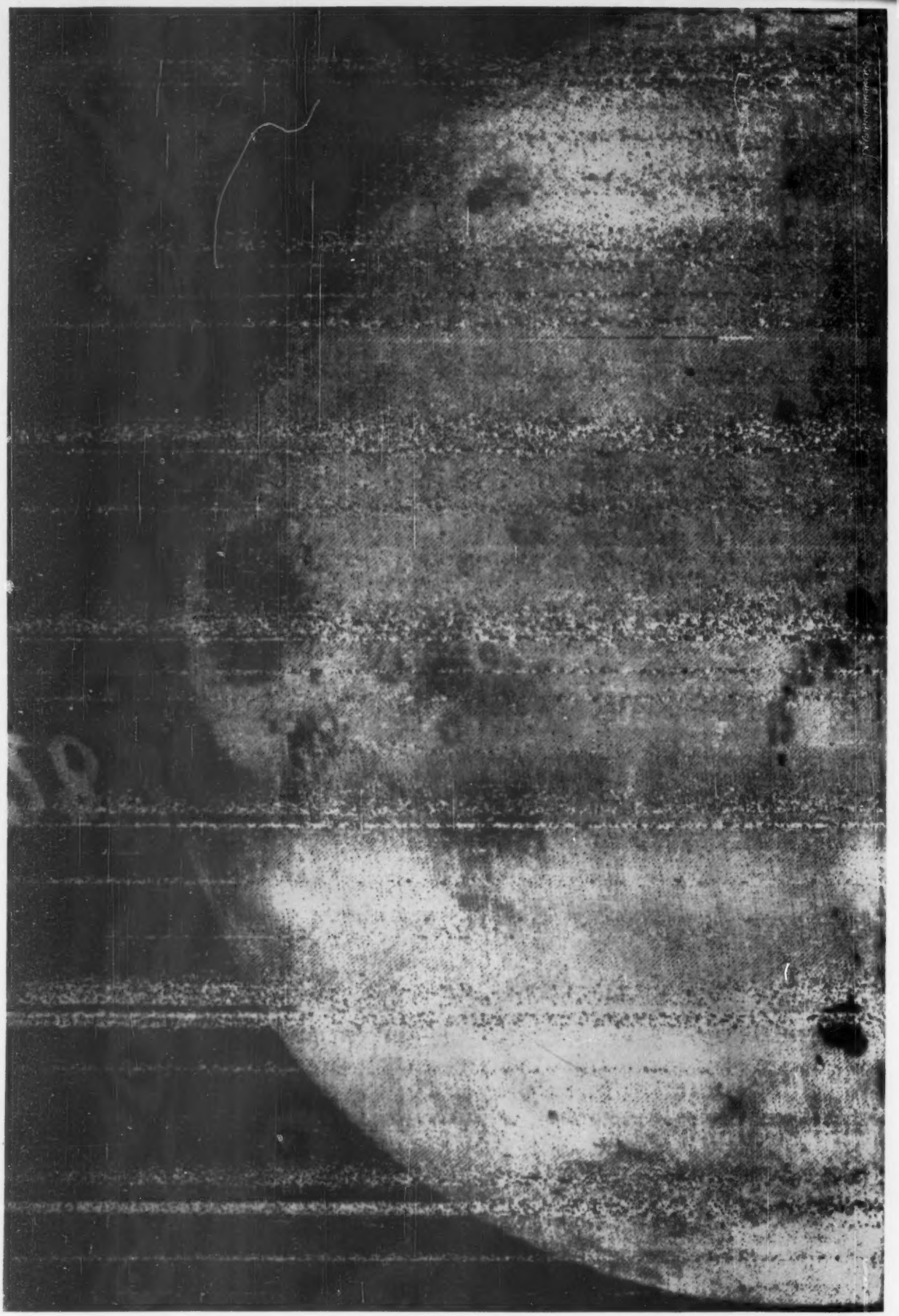
The star is No. 215,441 in the *Henry Draper Catalogue*, where its visual magnitude is given as 8.6 and spectral class as *A*0p. The last letter indicates that the spectrum is peculiar, which led Dr. Babcock to examine it for the magnetic effect. He procured 20 spectrograms between July 14, 1959, and June 13, 1960, all showing evidence for an unusually strong magnetic field of positive polarity.

Several of the metallic lines, such as those of ionized titanium and chromium at 4163 and 4558 angstroms, respectively, were resolved into the fine components of the Zeeman pattern, permitting accurate measurement of the magnetic field strength involved. On four plates taken on successive nights from October 23rd to 26th, in 1959, a value of 34,400 gauss was obtained for the magnetic field. This is about twice that of the strongest of the 100 magnetic stars heretofore known. The earth's field is a little less than one gauss, and the sun's only slightly more.

Lesser strengths found on other spectra indicate that the magnetic field of the Lacerta star changes markedly in an irregular fashion, sometimes being as low as about 12,000 gauss. The polarity remains positive, and Dr. Babcock believes that the star's rotation and magnetic axes lie nearly in the line of sight.

The radial velocity varies erratically, and the brightness alters by 0.15 magnitude in a 9.5-day cycle, neither phenomenon being synchronized with the magnetic field variation. One spectral peculiarity is that the H and K lines of ionized calcium of this star appear to originate in a slowly expanding shell, located about 1.2 stellar radii above its surface.

Dr. Babcock, writing in the November, 1960, issue of the *Astrophysical Journal*, calls attention to another remarkable feature of HD 215441. Inside a normal star, the weight of each layer is supported by gas pressure and radiation pressure. In this case, however, the magnetic forces are so great that they furnish the chief support for the outer layers. He further believes that the strong, fluctuating magnetic field causes the ejection of much material from the star. The amount of internal magnetic energy is probably at least equal to that of the total radiant energy it sends into space each 37 days.



Charting the Hidden Side of the Moon*

Y. N. LIPSKY, *Sternberg Astronomical Institute, Moscow, U. S. S. R.*

AS IS WELL KNOWN, on October 4, 1959, the Soviet Union launched its third cosmic rocket, which orbited an automatic planetary station (APS). The latter followed an orbit around the moon and returned toward the earth. Photographing the surface of the other side of the moon was begun, by a special command, at 3:30 Universal time on October 7th, at a distance of 65,200 kilometers from the moon's center.

The photographing ceased 40 minutes later, when the APS was 68,400 kilometers from the lunar center. The exposure times were changed automatically. The camera had two objectives, with focal lengths of 200 and 500 millimeters, providing lunar images about 10 and 25 millimeters in diameter.

When a photograph had been made, the miniature camera developed, fixed, and dried the specially prepared 35-mm. film that was used to allow processing at a very high temperature. For televising to Earth, the negative image was converted into electric signals; the changes of the signals were determined by the change in the transparency of the negative along the scanning lines.

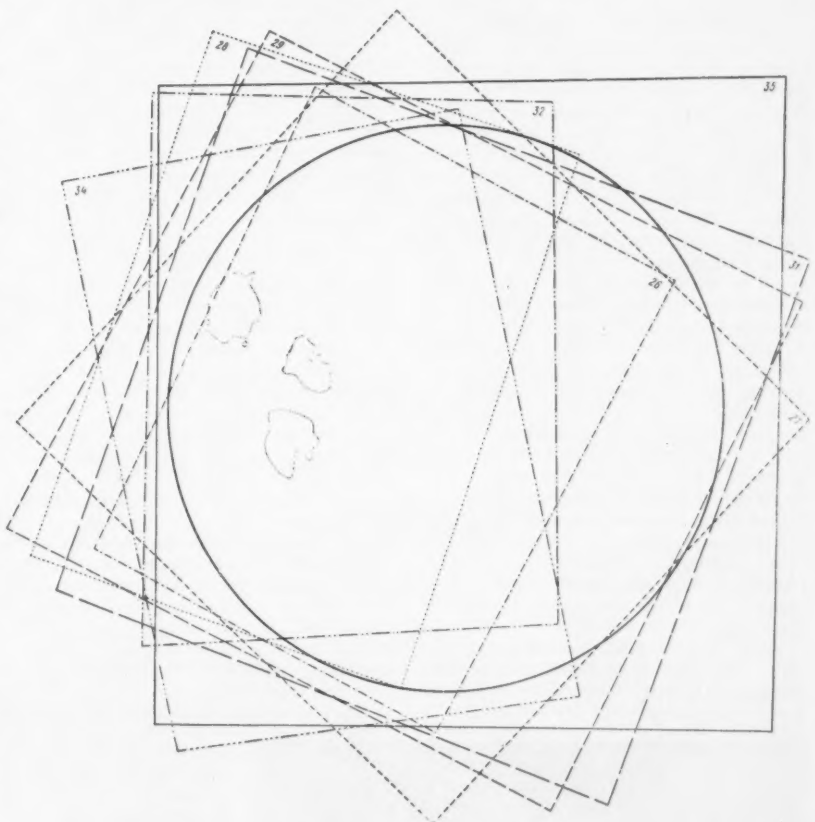
To reduce the effect of noise, the signals of the image were modulated before being transmitted. When received at terrestrial stations, these signals were stored on magnetic tape and then, after demodulation, were recorded on different types of apparatus. Here we mention only the photorecorders that reproduced the images of the original APS negatives on 35-mm. film, and the magnetic recorders that produced the image from magnetic tape recordings. On the photorecorders, the images were about 10 and 25 millimeters in diameter, but were 10 times larger on the magnetic recorders. The details of the transmission process have been reported in an atlas published by the U. S. S. R. Academy of Sciences.

In Moscow, the Sternberg Astronomical Institute, together with the Central Scientific Institute of Geodesy, Aerial Photography, and Cartography, analyzed all data obtained. These organizations developed methods for interpreting the details of the lunar photographs, compiled a catalogue describing all recognizable formations, measured their coordinates, calculated the cartographic projections, and drew up a final map. The photographs were studied simultaneously and independently at the Pulkovo Observatory near Leningrad and at the Kharkov State University Observatory.

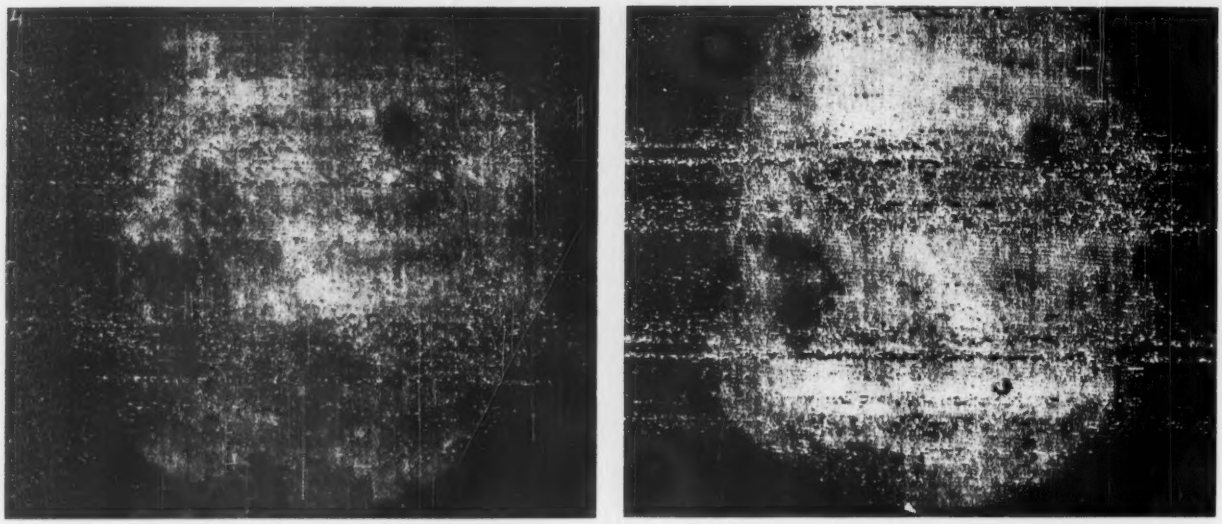
Interpreting the pictures involved two fundamental difficulties – the moon was almost full, as seen from the APS, and without exception all of the photographs had varying amounts of imperfections. Anyone who has examined full-moon pictures taken from ground observatories knows that it is extremely difficult to identify many familiar features. This is due to the lack of shadows and consequent loss of contrast. The density, size,

*This is the text of an article by Dr. Lipsky in the U. S. S. R. *Astronomical Journal, 37,* 1043-1052, 1960, "A Method for Studying the Reverse Side of the Moon and Results Obtained." The translation into English, by Richard M. Holden and Burton Hobson, has been freely edited by the staff of this magazine. It was translated for the Geophysics Research Directorate, Air Force Cambridge Research Laboratories by the American Meteorological Society, under contract AF19(604)6113.

FACING PICTURE: One of the Lunik III lunar photographs, televised to earth in October, 1959. To make its details clearer, the negative's transmitted characteristics were subjected to an electronic filtration process that retained a limited range of intensities, then increased the contrasts within that range. (Cross section data: I = 0.70C, range of A = 0.60C.) North is toward the top. The large dark oval at the left is Mare Crisium; the conspicuous dark spot at lower right is the newly discovered crater Tsiolkovsky; at the extreme top can be seen large craters near the moon's north pole. Illustrations with this article, unless otherwise credited, are from "Atlas of the Opposite Side of the Moon," by N. P. Barabashev, A. A. Mikhailov, and Y. N. Lipsky, Moscow, 1960. The text and catalogue of about 500 lunar features are being translated into English by Richard Rodman of Harvard Observatory, and the entire volume will be published jointly in the near future by Interscience Publishers, Inc., and Sky Publishing Corporation.



These numbered squares identify the fields of different negatives of the moon's far side. The changes are due to the space probe's varying orientation during the 40-minute interval while pictures were being taken.



The author's photographs 1 and 2. The photographic masking technique described below was used to make these prints from photometric cross sections of negatives 29 and 31. At the left, contrasts are fairly normal, showing general features. At the right, contrasts are strong for bright regions.

and location of the defects relative to the lunar surface's image varied on different exposures. Thus, by comparing the details on several negatives we were able to test their reality.

We used various methods to bring out the details on the photographs. The principal ones are described here.

Superposition of Negatives

When several negatives of the same object, taken under identical conditions, are superposed and viewed by transmitted light, the details on them become more clearly visible. But because the imperfections are randomly located on the different negatives they do not add up. This method made it possible to obtain exceptionally clear photographic images of the moon. In our case, the problem was complicated by the fact that the radio interference took the form of rather broad bands, consisting of a large number of points of varied density. Hence, we modified the method as follows:

Three film projectors were set up, each containing a different negative, and were used to project superimposed images. By turning the projectors properly, the edges of the lunar images could be made to coincide, and we could get the best possible coincidence of those features that were clearly visible on all three negatives. These included Mare Humboldtianum, Mare Marginis, Mare Australe, the Moscow Sea, the crater Tsiolkovsky, and others. Geometric distortions in some negatives were compensated by tilting the projected images of the moon.

Using this method, we were able to trace individual formations on a semi-transparent screen. We outlined reliably part of the boundary of Mare Smythii, discovered an apparently elevated light spot within the Moscow Sea, detected several formations to the northeast of the Soviet Range, and so forth.

However, the interference bands on the several negatives, located randomly with respect to the moon's image, greatly limited the area free of clutter. Furthermore, the bands are not in the same direction on each negative, for while taking the pictures the APS slowly rotated around its axis. In regions where the interference bands intersected, interpretation was completely impossible. In some cases, when it became difficult to use the tracing technique, a visual estimate was made of the actual difference in contrast between the individual details. In any case, the aforementioned disturbances greatly limited use of the superposition method.

Photographic Masking

Weak contrasts between neighboring regions on a negative can be intensified by using a photographic mask, when the maximum contrast between the individual regions of the negative far exceeds the photographic latitude of the printing paper being used. This condition occurred in the case of photographs of the far side of the moon. For example, in many negatives the regions of the Soviet Range, the crater Giordano Bruno, and areas north of it and northeast of the Moscow Sea, all differ sharply in density from Mare Crisium, Mare Foecunditatis, Mare Spumans, and the Sea of Dreams. At the same time, the contrast among the individual details within these regions is very slight. In certain cases, intensification of the contrast was possible by printing on contrasty paper, but elsewhere the details were lost completely.

The photographic masking method reduces extreme contrast between different regions of the negative without weakening the slight contrasts of features within these regions. Essentially, the method involves these steps.

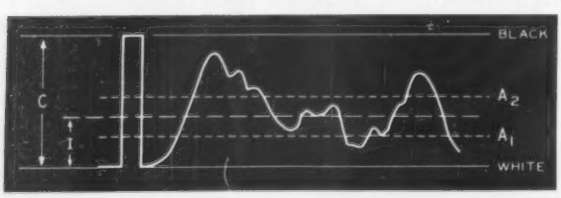
From a weak negative, we make a washed-out, indistinct positive on a transparent base, that is, a mask. The aim is to have the low-contrast fine details become indistinguishable on the mask due to equalization of density, so we use low-contrast film with its emulsion placed several millimeters from the negative. After exposure, the mask is developed until its range of densities is satisfactory.

This range was selected by trial. When the mask was superimposed on the negative and examined by transmitted light, the maximum contrast of the negative decreased sharply; brightest places of the mask corresponded to the darkest places on the negative, and vice versa. When the relative densities of mask and negative are properly chosen, the density of the masked negative differs from a constant value by an amount proportional to the actual density variations of the region to be interpreted.

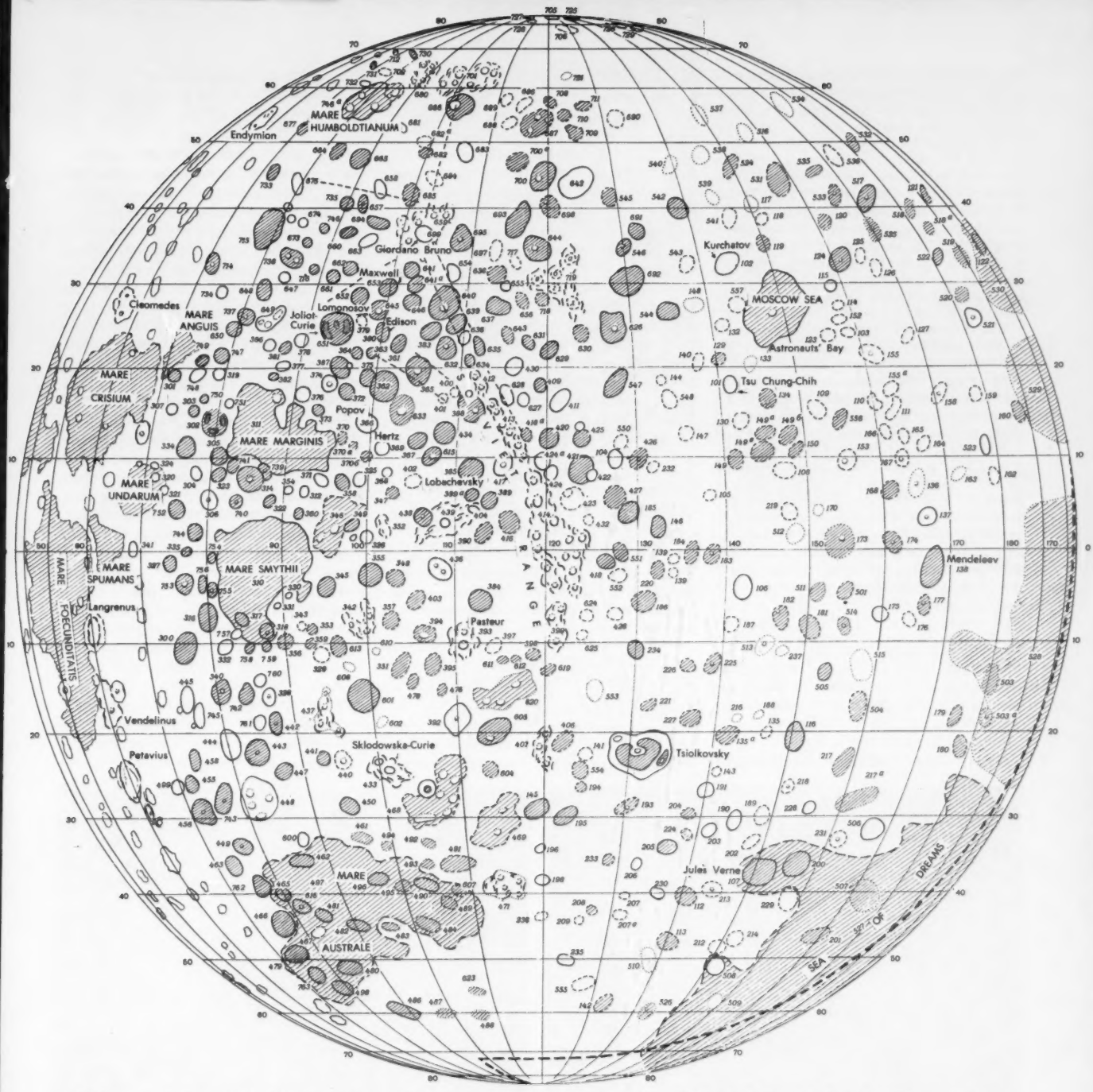
By adjusting the focus of the image on the mask, the density differences of the masked negative can be reduced to extremely small values. However, in this case, the negative and the mask must be made to coincide very accurately. We found the great number of defects often made it difficult to superimpose the two exactly and the combination became unclear.

Photographs 1 and 2 given in the *Atlas of the Opposite Side of the Moon* were obtained by masking the photometric cross sections (to be discussed below) of the original negatives 29 and 31. Quite clear pictures of the moon's far side were obtained in this way, but their maximum contrast is still very great.

Thus, in photograph 2 (from 31) the maximum contrast is great between, on one hand, the regions southwest and northeast of Mare Humboldtianum, southwest of Mare Smythii, the Soviet Range, and, on the other hand, the environs of Mare Marginis, Mare Australe, and Mare Crisium. The northern edge of Moscow Sea and the southwestern part of Mare Marginis can be



In this sketch, the irregular curve represents a density scan across a Lunik negative. A_1 and A_2 bound a photometric cross section of mid-level I, as explained in the text on page 136.



This map of the moon's far side was compiled from Lunik III photographs. Solid, dashed, and dotted outlines denote formations in the three categories: most, less, and least reliable, respectively. Features darker than their surroundings are shaded; if brighter, unshaded. Light dashed lines represent bright rays; the heavy broken line at lower right is the boundary of the still unobserved part of the moon. North is upward, and west longitude increases from the left. The region east of longitude 70° is from existing maps of the near side. From the "Astronomical Journal," U. S. S. R. Academy of Sciences.

seen clearly in this picture, which is sharper in many details than the unmasked prints.

In photograph 1, the maximum contrast also remained great, but the overall sharpness increased noticeably. It was easier to examine the outlines of the crater Jules Verne, the Sea of Dreams, individual details in Mare Australe, and the like.

From our experience with the photographic masking method, we became convinced that the slight contrasts on the negatives would have to be sharply increased if we were to detect most of the details. We did this in the following way.

Photometric Cross Sections

This fruitful method consists of repeated intensification of the weak contrasts by electronic techniques. This intensification was not performed simultaneously for the entire negative, but for chosen photometrically similar regions, whose densities fell between certain limits, as described below. The densities were matched to specific photometric "cross sections." To insure full exploitation of the method, electronics specialists were assigned to the instruments that reproduced the far-side images of the moon from the magnetic tape recordings in the laboratory.

When a recording was played back into one of the reproducing instruments, changes in the signal varied the density along the sweep line building up the image. For intensity calibration and to permit comparing different areas of the image, an auxiliary impulse, whose amplitude was kept strictly constant, was injected at the beginning of each sweep line. The value of this impulse, C, corresponded to the signal from the black part of the negative in the satellite. At the opposite extreme, the video signal that transmitted the background fog set the

zero level in the reproducing instrument.

The values of these two video signals, one from the black and one from the white portions of the negative, were the basis for estimating the relative densities of the negative and the contrast of its details. The reproducing instrument could reconstruct all densities in the interval from zero to C, and if a range of amplitudes being reproduced was smaller than this interval, it could be amplified. In fact, the smaller the range of amplitudes to be converted into the image in the instrument, the larger the allowable intensification factor, its maximum value being 100 in our apparatus.

The photometric cross section corresponds to the amplitude interval $\Delta A = A_2 - A_1$, expressed as a percentage of C. For example only signals between $A_1 = 0.60C$ and $A_2 = 0.65C$ might be admitted into the instrument by its limiters. In this case, all parts of the original negative with signal values less than 60 per cent of C would be reproduced as white, while those exceeding 65 per cent of C would be black on the new negative. Intensification of the contrast differences among details in the reproduced region could be 100 in this case. If ΔA were increased to the range between $0.50C$ and $0.70C$, however, the intensification factor would be correspondingly decreased.

When interpreting dense parts of a negative, ΔA is selected at relatively high values of A, while for low-density regions small A numbers are used. The height I of the photometric cross section is defined as the average value of the interval of amplitudes recorded by the instrument, expressed in terms of C:

$$I = \tfrac{1}{2}\,(A_1 + A_2).$$

In some cases, ΔA must be expanded to values close to C, and little amplification is possible. The photometric cross section from original negative 31, mentioned earlier, was obtained with $I = 0.66C$ and $\Delta A = 0.60C$, while for negative 29 both these values were $0.63C$. Thus, these photographs do not have much intensification, yet we can identify in them the clearest and largest formations on the opposite side of the moon — the Moscow Sea, the craters Tsiolkovsky, Jules Verne, Mendeleev, Kurchatov, Lomonosov, and others. There are also many areas differing in their reflecting properties, suggesting near-side photographs at the time of full moon, when most lunar details become diffuse bright or dark spots.

This rough key has been prepared by the editors of "Sky and Telescope" for major features in the pictures below.

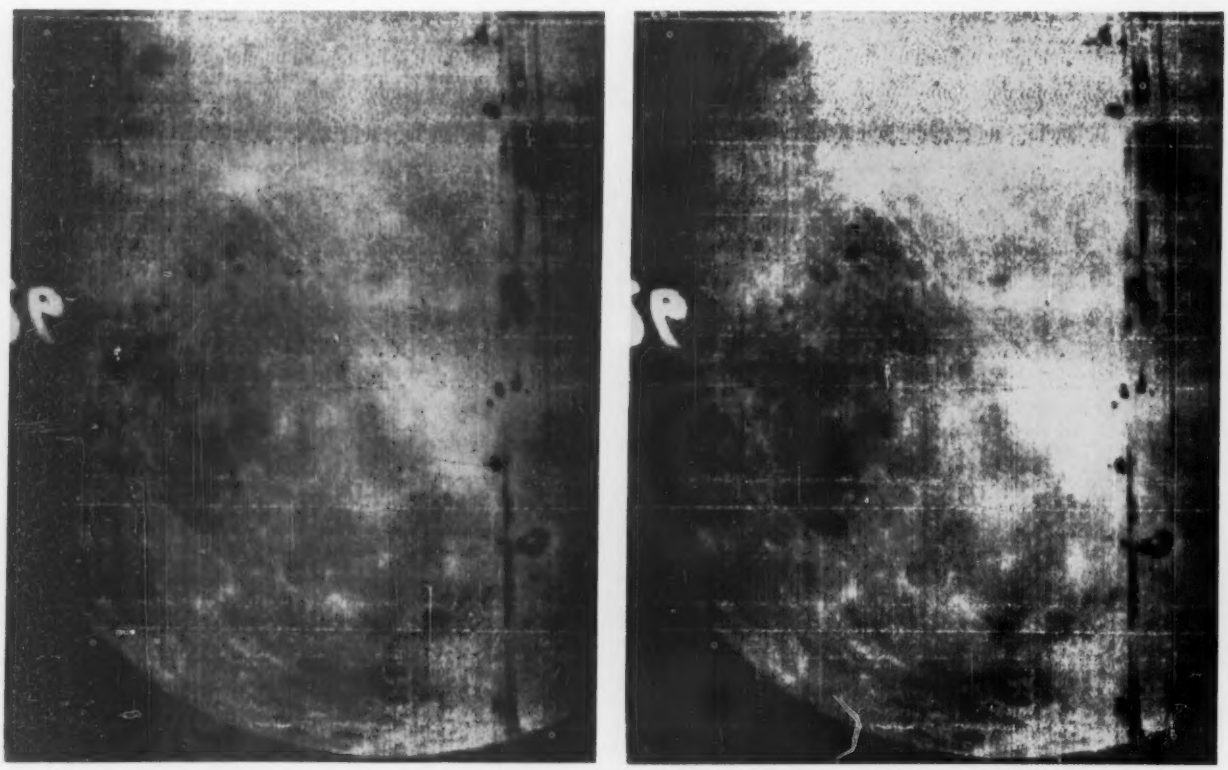
Examining the Reproductions

On **photographs 1** and **2** can be seen details located on the western part of the nearer lunar hemisphere, for example, the craters Endymion and Neper, Mare Crisium, and Mare Undarum. These familiar features in the Lunik photographs made it possible to orient the co-ordinate grid correctly and to determine the latitudes and longitudes of the newly detected formations. Their identification is a check on our accuracy in interpreting the photographs and in plotting the details on the map.

Many limb objects, observed from the earth only with extreme foreshortening, were for the first time observed practically without distortion. Among these are Mare Humboldtianum, Mare Smythii, Mare Marginis, and Mare Australe.

Photograph 3 is a positive of the large-scale original negative 26, with $I = 53$ per cent and $\Delta A = 71$ per cent of the interval C. It shows clearly many details near Mare Crisium, Mare Marginis, Mare Smythii, and westward (toward increasing selenographic west longitude). Many small dark spots that suggest craters appear in the region of Mare Australe, a number of them being located beyond longitude $+90°$. The central hill of the crater Neper is a little bright spot.

This picture reveals more clearly than



The author's photographs 3 and 4, both from original negative 26. The former covers a wider photometric cross section, hence shows detail in certain areas that are blank in the latter. See key chart at the top of this page.

do the small-scale photographs 1 and 2 the configurations of the four seas mentioned above, but their outlines do not agree with the imperfect delineations familiar to us. The bright rays coming from Giordano Bruno in the direction of the Soviet Range can be distinguished against the background of other objects; they appear to be analogous to the ray systems of craters Tycho and Kepler.

Changes in the reflecting properties of different regions are interesting. Besides the many small bright formations in the lower left part of the photograph, we note extensive areas of similar albedo. In this picture and others, it seems that the average albedo of much of the far side of the moon exceeds that of the limb zone.

However, a considerable number of objects in this photograph cannot be interpreted. Vast regions located northwest and west of Mare Humboldtianum, north and west of Bruno, southwest of Mare Australe, and elsewhere are filled with details of small contrast differences. The region of the Soviet Range is almost a solid white area in which individual formations are practically indistinguishable. Besides the imperfections affecting the entire negative, there are also black bands and spots near the right edge of the frame — evidently defects in the emulsion of the original film.

Photograph 4 shows a photometric cross section of original negative 26, made with $I = 0.60C$ and $\Delta A = 0.55C$. It differs substantially from the preceding pictures. Much of the lunar surface's intensity was outside the recorded interval and turned blank. The Soviet Range, an area adjacent to Bruno, and other sections appear as uniformly white fields. But some other details are sharper.

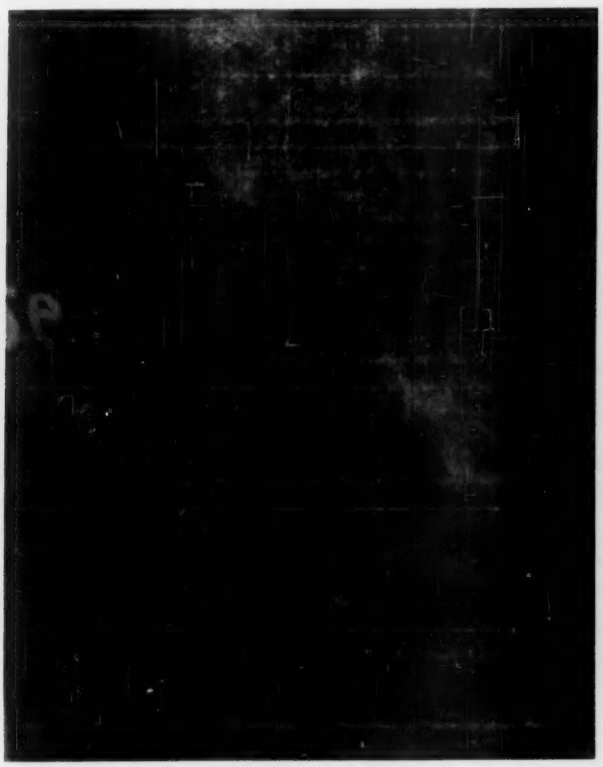
In the upper left, between Mare Humboldtianum and Mare Marginis, many hitherto indistinguishable features show up. Certain small objects in this region also turned blank. Evidently, some of them are craters, appearing as white spots under the high solar illumination. The southwest and south boundaries of Mare Smythii gain greater contrast, and there are more details between there and Mare Australe, whose conspicuousness is improved. Most of Mare Australe is substantially brighter than the interiors of Mare Smythii and Mare Marginis. The white spot on the west wall of Tsiolkovsky is plainer. Another weak bright ray stretches northeast from the Soviet Range.

Photograph 5 shows the next photometric cross section of the same negative 26, made with $I = 0.70C$ and $\Delta A = 0.10C$. The intensification factor of 40 is greater than in the preceding cross section (photograph 4). In other words, the difference in contrast of "gray" details, reproduced by signals whose amplitudes were from 65 to 75 per cent that of the auxiliary impulse, was intensified by almost 40 times. Much of the hidden lunar surface had reflection coefficients smaller than those areas recorded with $A_1 = 0.65C$. Thus, the maria Crisium, Spumans, Humboldtianum, Australe, Smythii, Marginis, and the craters Lomonosov, Joliot-Curie, Edison, and Maxwell disappeared or became very black. Some sections of the Soviet Range and the area near latitude +60° appeared very bright.

This cross section was selected to facilitate interpretation of areas near Bruno and the Soviet Range that differed little from them in intensity. The photographs reveal irregularities inside Bruno and show parts of its rim. Southwest of it a little white spot is visible, apparently an elevation. The bright area surrounding this crater in the preceding cross section is now resolved into separate details. At the photometric level of this cross section are recorded features in the area numbered 701 on the chart, at latitude +63° and longitude +100°.

Formation 666, at +56°, +102°, is shaped somewhat like Mare Humboldtianum, but did not appear in the earlier photometric cross sections. Now we can even note some structure inside it — a bright round patch near the eastern edge is clearly visible on the dark background. Since in this cross section all gray features (neither white nor black) differ in intensity by not more than 10 per cent, the light spot inside 666 nearly agrees in brightness with the surroundings of Bruno and with certain areas near the Soviet Range. Inside the dark object 687 (+53°, +117°) small, bright spots are visible.

Photograph 6 is still another cross sec-



Photographs 5 and 6 both have high, narrow cross sections, so large expanses of fainter surface appear blank. Details of the Soviet Range (bright area right of center) are seen, although this area was featureless in some other views.

tion of the same negative, made with $I = 0.60C$ and $\Delta A = 0.10C$. Due to the reduction in value of I, compared with photograph 5, fairly extensive regions become white. The outlines of the bright ray going from Bruno toward the Soviet Range and across the ring formations 640 (+27°, +107°) and 639 (+25°, +109°) have become visible. Many details are revealed in the region between latitudes +10° and +30° and longitudes +110° and +130° that were scarcely detectable in the other cross sections. A number of bright markings have appeared in the Soviet Range and to the south, while the outlines of Mare Humboldtianum and of Tsiolkovsky and other craters can be traced.

Results from the Photographs

The photometric cross sections we have described are only a few examples of some 200 made from the original negatives. The program of electronic reproduction was based on the photometric peculiarities of the regions to be interpreted. Study of all the material revealed 499 objects in the photographs taken by the APS on October 7, 1959. Of these, about 100 formations are observable from the earth, but many of their outlines and co-ordinates were obtained more precisely than given on existing maps of the moon.

All the formations recorded have been divided into three reliability categories. In Class I belong objects identified in photometric cross sections of three or more of the original negatives and which have distinct outlines. Their positions and shapes have been reliably established. This first category includes the 100 formations observable from the earth.

Objects identified on cross sections of at least two original negatives, but with outlines that are not everywhere clear, belong in Class II. The accuracy of their outlines can be improved by future photographs at other phases of the moon. Finally, formations appearing on the photometric cross sections of one original negative, or found on several negatives but with very indistinct contours, constitute Class III.

Of the objects charted on the large map, 252 belong to the first category of reliability, 190 to the second, and 57 to the third.

Let us examine a few of these objects in some detail, beginning with Mare Humboldtianum, which is centered at latitude +57°, longitude +80°. From Earth, this sea is observed at the very edge of the visible disk of the moon under favorable libration. Its outlines on existing maps are greatly distorted by perspective. On our pictures, it is a sharply bounded dark formation on a lighter background. Only in the west is a part of its edge less distinct. As viewed from the APS, with nearly full-moon illumination, the sea's east part is darker, gradually lightening to the west, where it approaches the brightness of its surroundings. A number of craters can be seen within it; they are darker in the eastern part. Mare Humboldtianum stretches 250 kilometers from north to south and 180 from east to west.

The co-ordinates of the midpoint of Mare Marginis are +12°, +88°. It too is observable on the limb of the earthward disk only during favorable libration. On prints made from our original negatives and on their photometric cross sections, Mare Marginis appears as a light area with very sinuous boundaries. It is located between +8° and +18° latitude and +82° and +96° longitude. Inside it are a number of dark-floored craters. The region to the north, between latitudes +18° and +24°, longitudes +83° and +88°, has a different albedo and should not be included in Mare Marginis. The same remark applies to the area to the east of this sea, from +12° to +18°, between +76° and +81°.

The area of the moon's north pole, from a portion of photograph 23 in the Moscow atlas. Several of the large polar craters mentioned in the text are clearly recognizable at the upper right, and a portion of the Moscow Sea appears at lower right. Mare Humboldtianum is visible as a dusky patch at the left edge.

The craterlike objects that form this region are brighter than the surface of the sea. The longest diameter of Mare Marginis is almost 450 kilometers (from +18°, +83° to +9°, +95°). It is some 200 kilometers across in the direction from +10°, +81° to +16°, +92°.

Mare Australe, centered in latitude −40°, longitude +95°, is only in part visible to terrestrial observers, even when the moon's libration is the most favorable. As revealed by our photometric cross sections, it is an extensive region of low albedo. Inside, this sea has many craters with dark floors. Its borders, now accurately charted for the first time, show it to be bounded by latitudes −33° and −59°, longitudes +70° and +111°. The outline, however, is quite irregular. Its darkest parts are symmetrical with respect to longitude +90°. In −40° latitude between longitudes +95° and +111°, the sea's surface is brighter. On the north, west, and south, Mare Australe is surrounded by regions of high albedo. This huge sea is almost 1,000 kilometers across.

The foregoing examples illustrate how many details on the moon's western limb extend onto its normally invisible portion. Of even more interest are the formations wholly on the hidden side. Among these is the very dark Moscow Sea, located at +27°, +149°. It appears in all the photometric cross sections as a dark, slightly elongated feature on a light background. Its southern part protrudes to form Astronauts' Bay. The brightness of Moscow Sea is not uniform, indicating a surface of varying elevation. Approximately in its center there is a bright object resembling a small hill. From the cross sections of negative 29, we find the albedo of Moscow Sea to be higher than for Mare Smythii and Mare Marginis. This formation stretches almost 300 kilometers from northwest to southeast, and 200 kilometers from west to east.

A group of craters with very clear relief is located close to the north pole of the moon. When the APS photographs were made, the phase angle of the moon was about 17 degrees. Since the evening terminator was near these craters, the shadows of their walls were clearly visible in the photographs. The crater numbered 705 on the map, at latitude +88°, longitude +120°, appears in the reconstructed pictures as bright on a gray background. Because the terminator was so close, the image of this crater is much like the usual view of craters in ordinary moon pictures. Wall and floor are both clearly evident, the wall appearing darker than the surrounding surface, which dif-

fers little in albedo from the floor. The diameter is about 150 kilometers.

Crater 725, at +85°, +175°, is another conspicuous member of the north polar group. A dark crater on a gray background, it can be seen clearly in excellent relief near the evening terminator. The floor is darker than the environs. Its southeast wall has a lower albedo than the outside, but higher than that of the crater bottom. The wall shadow is clearly visible in the photographs, and the sunlit northwest rim appears as a bright curved arc. Greatly foreshortened, the crater appears about 180 kilometers long and 40 wide. The images of craters 726 (+79°, +169°) and 729 (+77°, +170°) come out as sharply as those of 705 and 725.

Among the most noteworthy craters on the moon's hidden side is Tsiolkovsky, at latitude −22°, longitude +131°. Its image shows up very well, even through defects, on all original negatives. The photometric cross sections made it possible to clarify the quite complex structure of this formation. Its floor is distinguished by low albedo, but is irregular in brightness. The surrounding surface is considerably lighter. Enclosing the entire formation is a broad wall, which is noticeably lighter in the west. There is also a brighter region on the northwestern rim. In the southwestern part is a dark patch containing a bright spot. Centered on the floor is a light area with a bright core, evidently a hill. Between the hill and the north edge is a strip of higher albedo than the rest of the floor. From east to west, the diameter of Tsiolkovsky is about 200 kilometers, and it extends about 150 kilometers from north to south.

The Soviet Range lies mainly in latitudes −5° to +9°, longitudes +118° to +124°. The general trend, interrupted in places, is toward the northeast, and there is a noticeable broadening near the moon's equator. The range's brightness is that of mountainous regions on the moon's near side. On the original negatives, the Soviet Range is a region of slightly varying high density. High photometric cross sections made it possible to recognize the structure of this formation.

A decrease in albedo is noted along the range's southwestern part, and the southern section is resolved into individual bright details. Light areas are also noted in the northern portions. Obviously, the entire formation is hilly, consisting of many individual uplifts. The heights of individual peaks should be measurable on future photographs taken when the Soviet Range is near the terminator.

It is natural to include objects 399 (−8°, +122°), 412 (+18°, +112°), and 413 (+14°, +115°) in the Soviet Range, since they resemble it in both structure and albedo. This would make the total extent of the mountain chain almost 1,000 kilometers.

On our map, Giordano Bruno, at latitude +36°, longitude +103°, is numbered 699. This is one of the brightest crater-like formations on the moon's far side, appearing only in very high photometric cross sections, while its surroundings also have a very high coefficient of reflection. A system of bright rays diverging from Bruno is clearly seen, one ray being very readily traced toward the Soviet Range across formations 640 (+27°, +107°) and 639 (+25°, +109°).

We have described here only a few of the important objects on the moon's hidden side. Study of all our data leads to the following general conclusions.

The two hemispheres of the moon are unlike in that there are no extensive depressions on the far side like Oceanus Procellarum and Mare Imbrium on the near side. Most of the latter two seems more than 2,000 meters lower than the general level. [See contour map on page 84 of last month's SKY AND TELESCOPE.] There are no such large basins on the far side. Although the combined area of the Moscow Sea and the Sea of Dreams about matches Mare Imbrium, the former are probably quite shallow. This remark particularly applies to the Sea of Dreams, whose albedo, judging from a large number of photometric cross sections, differs little from that of many parts of the adjacent surface. The assumption that there is an extensive lowland on the moon's opposite side near the western limb, continuing the belt of the seas, was not verified.

Formations on the farther hemisphere are not different in nature from those on the visible side. The presence of crater images in the photographs is beyond any doubt. The photometric cross sections of all the original negatives make it obvious that regions rich in bright craters occupy a large part of the hitherto unobserved side. We have also mentioned the ray systems and mountain ranges.

Left uncharted by the Lunik cameras is a sizable part of the moon's surface that is located beyond the eastern limb as seen from the earth. When new photographs of the moon are taken from space, at other phase angles and from other directions, our newly won information should be supplemented and made more accurate.

The author wishes to thank his colleagues at the Sternberg Astronomical Institute, L. A. Bondarenko, K. I. Degtiareva, and A. I. Goina, for their assistance in this work.

QUESTIONS... FROM THE S&T MAIL BAG

Q. How many professional observatories are there in the world?

A. The *American Ephemeris* for 1961 lists 315 observatories and 27 additional radio installations. A number of them are field stations, and some are private observatories operated by advanced amateurs.

Q. When did the path of a total or annular eclipse of the sun last cross Florida?

A. There was a total eclipse visible from Florida on June 8, 1918, and an annular one on April 7, 1940. Floridians will see their next total eclipse on March 7, 1970.

Q. Does Neptune's outer satellite, Nereid, move in a retrograde orbit?

A. No; it moves from west to east around Neptune, in the opposite direction from the inner satellite, Triton. Nereid's orbit, however, is the most strongly elliptical one known for any natural satellite, the eccentricity being 0.75. The distance between this moon and its primary ranges from one to six million miles.

Q. What characteristics of a camera or telescope determine the exposure time in photographing point sources of light, such as stars, compared with extended objects, such as the moon or a nebula?

A. All the light from a star can be focused to one small spot on a photographic plate, so the exposure depends on the telescope aperture. A 6-inch telescope requires only about a quarter the exposure time of a 3-inch, as it gathers four times as much light. For an extended object, however, surface brightness rather than total light is the determining factor, and the exposure depends on focal ratio. A 3-inch f/6 telescope (18-inch focus) will be just as fast as a 6-inch f/6 (36-inch focus), but the picture scale will be twice as large in the latter case.

Q. How can I find the day of the week for a date such as November 11, 1918, if no calendar is available?

A. One method is to divide the Julian day number of the date by seven. The remainder indicates the day of the week, 0 for Monday, 1 for Tuesday, and so forth. The Julian day numbers are a consecutive count of days from January 1, 4713 B.C., and can be found from conversion tables in the *American Ephemeris* (for example on pages 445-47 of the volume for 1961). Thus, November 11, 1918, at Greenwich noon was the commencement of JD 2,421,909. This number is exactly divisible by seven, hence Armistice Day was a Monday.

Q. What is a zenith telescope?

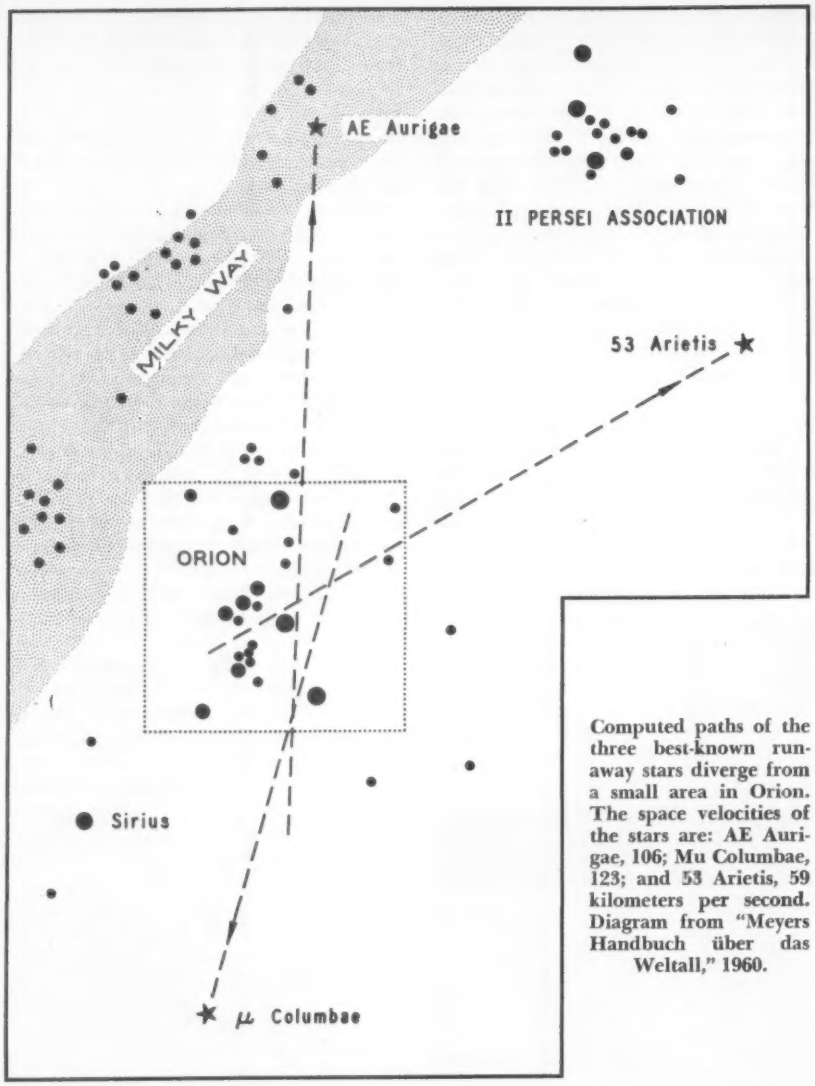
A. It is a visual instrument for determining latitude by measurement of the difference in zenith distances of two stars, one passing north of the zenith, the other south. The zenith telescope consists of a small refractor attached to a vertical column, and fitted with an eyepiece micrometer and very delicate spirit levels.

W. E. S.

Runaway Stars

OTTO STRUVE

*National Radio Astronomy Observatory**



Computed paths of the three best-known runaway stars diverge from a small area in Orion. The space velocities of the stars are: AE Aurigae, 106; Mu Columbae, 123; and 53 Arietis, 59 kilometers per second. Diagram from "Meyers Handbuch über das Weltall," 1960.

ADRIAAN BLAAUW, who is director of the Kapteyn Institute at Groningen University, Netherlands, has introduced the term *runaway stars* to identify a small class of very hot stars of spectral types *O* and early *B* with unusually rapid space motions. They are massive young objects of stellar Population I, but do not have any striking spectroscopic features that would set them apart from slower moving stars of similar spectral types. The vast majority of *O* and *B* stars have radial velocities of the order of 10 kilometers per second, whereas the runaways range between 30 and 100.

These Population I objects are not to be confused with the ordinary so-called high-velocity stars. The latter are very old members of Population II, such as the RR Lyrae variables, whose galactic orbits are not confined to the central plane of the Milky Way. Because they do not partake of the rapid rotation of the spiral arms around the system's center, they appear to be falling behind with great speed — hence the term high-velocity stars.

Blaauw has shown that any simple statistical law describing the velocity distribution of *O* and *B* stars moving slower than 30 kilometers per second fails to fit the numbers of the faster stars. Hence, the runaways appear to represent a distinct class whose kinematical properties differ from those of slower early-type stars.

The most famous runaway stars are AE Aurigae, Mu Columbae, and 53 Arietis, whose spectral types are *O*9, *B*0, and *B*2, respectively. All three are at about the same distance from us as the Orion stellar association and the great Orion nebula. They seem to have escaped from the association, Mu Columbae about two million years ago, AE Aurigae three million, and 53 Arietis nearly five million years ago.

Recently Blaauw collected the best available data for more than a dozen other rapidly moving *O* and *B* stars, and showed that most of them probably originated in stellar associations, from which they were expelled with relatively high speeds. On the assumption that these stars have moved at constant rates, he computed their kinematical ages by dividing their space velocities into their present distances from the parent associations.

A few years ago, it seemed reasonable to identify the kinematical age of a runaway star with the evolutionary age of the group from which it came. V. A. Ambarzumian and Blaauw had independently demonstrated that several stellar associations are, in fact, expanding. Many astronomers believed that all members of an association had equal ages. It followed from this viewpoint that, as an association was disrupted by the attractions of other stars and of the Milky Way as a whole, the runaway stars were simply those that at the start had acquired the fastest motions. Therefore, they traveled farthest from the original center of the group.

However, a new and different hypothesis was presented by Blaauw in August, 1960, at the international summer session for astronomers at Nyerode Castle in the Netherlands. He had noticed that although runaway stars do not differ spectroscopically from low-velocity *O* and *B* objects, there are two very important statistical differences.

First, the presently known runaways are all single — none is known to be a spectroscopic or visual binary — whereas about half of all ordinary *O* and *B* stars are binary systems. Second, among the runaways, stars of type *O* are about 10 times as common relative to type *B* as they are among low-velocity *O*5 to *B*5 stars.

To explain these facts, Blaauw proposes that the runaway stars originated in massive binary systems whose heavier components exploded as supernovae a million or more years ago. This is an independent formulation of a hypothesis advocated by F. Zwicky in 1957.

*Operated by the Associated Universities, Inc., under contract with the National Science Foundation.

Imagine that the heavier component of a binary could be suddenly annihilated. Its companion would no longer be restrained to move in a circular or elliptical orbit, but would fly off at a tangent, traveling through space along a straight line with the speed it had in its orbit before being released.

Of course, the sudden annihilation could not be complete, since only a very small fraction of the primary's mass is convertible into radiation. Suppose, however, that the heavier component exploded as a supernova, expelling most of its mass as an expanding shell of gas. As long as this shell had a radius smaller than the binary orbit, the motion of the companion would remain essentially unaltered. After the shell had become considerably larger than the orbit, its gravitational effect on the companion would be zero. The latter would then be moving much faster than the escape velocity associated with the remaining fragment of the primary star. Under these circumstances, the companion would move away along a nearly straight line, with a velocity somewhat smaller than it had in orbit originally.

For this process to work, the supernova shell must be propelled outward fast enough to reach the secondary's orbit within a time less than about half the binary's orbital period. This requirement places rather stringent conditions on the properties of the binary. Since the time scale of a supernova outburst is of the order of weeks or even months, the original binary cannot have a period of only a few days. It must be a wide pair of very massive stars whose orbital period is some few years.

Blaauw has made detailed computations of a variety of possible cases, showing that the mass of the primary before the explosion must have been between 100 and 1,000 suns. The following example is representative. Suppose that before becoming a supernova the primary had a mass of 250 suns, while the secondary (the star that is to become a runaway) had 25. A distance of 20 astronomical units between the stars would require a period of 5.4 years. If the supernova blew away nine-tenths of its mass during three months, the secondary would be released with a speed of 90 kilometers per second.

The very large masses Blaauw attributes to the primaries of his hypothetical binaries are well in excess of any we have observed in spectroscopic binaries. He therefore suggests that these peculiar, very massive primaries are highly unstable objects; they, and perhaps even the secondaries, have not yet fully contracted to become main-sequence stars. Hence he prefers to call the components *proto-primaries* and *protosecondaries*.

There are two varieties of supernovae, as R. Minkowski pointed out in 1940. Type I are more luminous, at maximum attaining a photographic absolute magnitude of about $-15\frac{1}{2}$, while Type II reaches about $-13\frac{1}{2}$. Only in the second kind is as much as nine-tenths of the star's original mass expelled. Hence the supernovae envisioned by Blaauw's hypothesis would be of Type II, occurring in associations at least as often as runaway stars are produced. Since three runaways are known to be related to the Orion association, at least three supernovae have exploded in the system during the past few million years, if the theory is correct. Blaauw suggests that some of the faint nebulous filaments observed by E. E. Barnard and E. P. Hubble to cover the constellation of Orion may be remnants of these supernovae.

M. Savedoff has argued that a single supernova explosion in Orion would not be sufficient to provide the amount of mass and momentum contained in the Barnard-Hubble nebulosities, as found by T. K. Menon in 1958 with Harvard's 60-foot radio telescope. This difficulty may be removed if, as Blaauw suggests, supernovae are occurring in the Orion association at the rate of perhaps one in a million years.

He believes that these explosions would produce shock waves in the dense ionized portions of the Orion nebula, these waves traveling about 10 kilometers per second and traversing 10 parsecs in a million years. Hence the state of the motions in the Orion nebula may be largely governed by such shock waves, as was also suggested by O. C. Wilson and his coworkers in 1959. A somewhat similar interpretation of the shock waves in the Orion nebula has been deduced by S. von Hoerner at the National Radio Astronomy Observatory.

An interesting sidelight to Blaauw's discussion is provided by the association I Persei, which is connected with the famous Perseus Double Cluster. This association is strikingly free of absorption or emission nebulosities. At the same time, the group contains many early-type supergiants, suggesting that conditions have been favorable for the formation of stars of large mass. The Dutch astronomer suggests that as many as 15 runaway stars may have escaped from this association since its origin. He believes that the succession of expanding shells from the supernovae could have swept the remaining diffuse material from the association, leaving it composed of stars only, without gas and dust.

One runaway star, Zeta Ophiuchi, is believed to have escaped from the II Scorpii association about a million years ago. There may have been earlier runaways from that group that are no longer identifiable. Blaauw offers the interesting conjecture that the long, dark lanes in the vicinity of Rho Ophiuchi were caused by the outflow of matter from supernova outbursts in that part of the Milky Way.

This five-hour exposure by F. E. Ross shows the wreath of nebulosity which envelops nearly all of Orion. The Great Nebula is just below center, with the overexposed belt stars above it. Yerkes Observatory photograph.

OBSERVING THE SATELLITES

First Solid-Fuel Satellite Launcher

THE "SCOUT" rocket system is scheduled to become the first all-solid-fuel satellite launcher in the United States' space fleet. It is designed to lift into orbit modest payloads for the National Aeronautics and Space Administration, or for other nations in co-operative programs for which Scouts will be made available. Under the general name Blue Scout, a series of adaptations of this vehicle are being applied by the U. S. Air Force to one of its research programs.

For a satellite that will orbit 350 miles above the earth, the Scout can handle a payload weight of 150 pounds. This figure becomes only 50 pounds if the probe package is to be hurled into a high trajectory, say out to 10,000 miles. While the system will thus be the weakest of NASA's boosters, it will also be the least expensive. The cost of making the entire vehicle, exclusive of payload, has been estimated at about three-quarters of a million dollars — less than a third of the comparable figure for the cheapest liquid-fueled launcher. These estimates do not include the highly expensive developmental work.

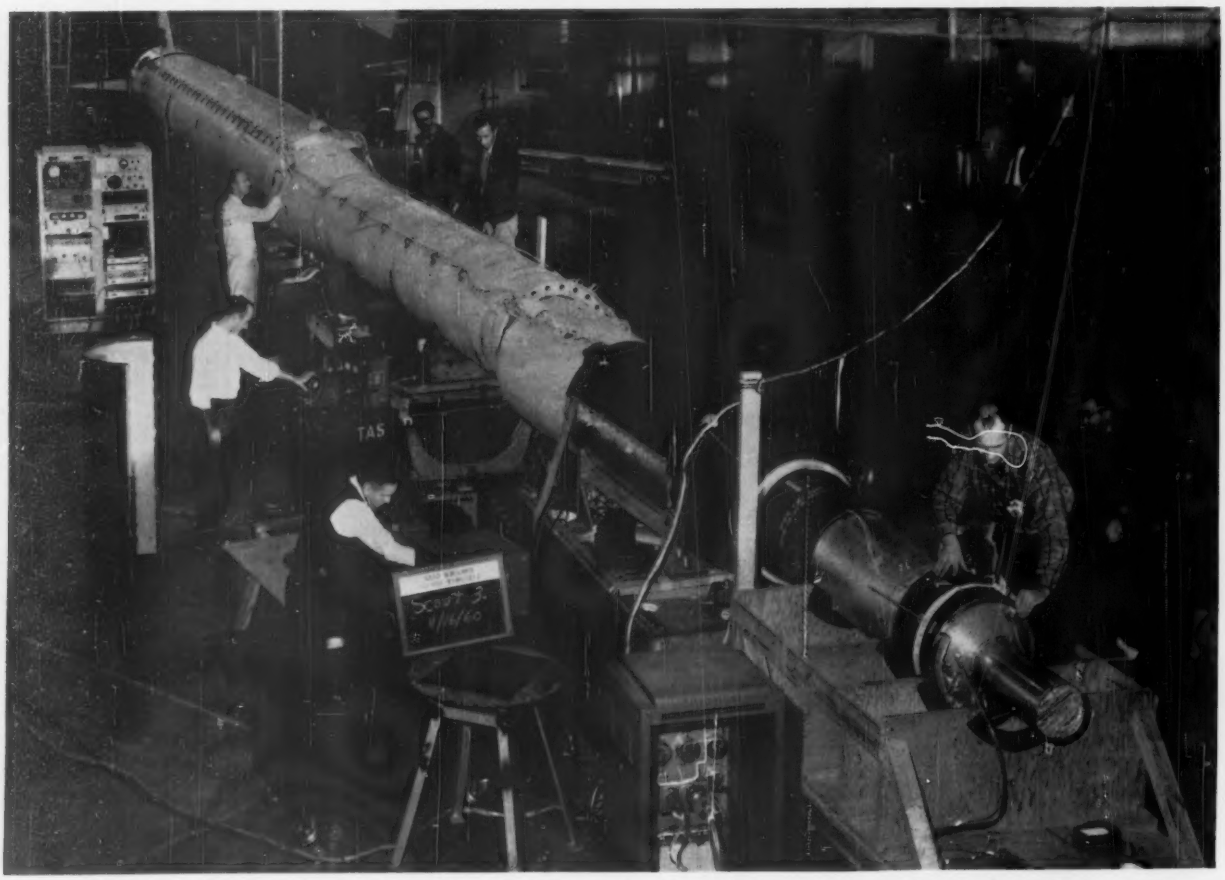
Prior to the Scout program, all of NASA's orbital shots were conducted from Cape Canaveral, Florida, and the only other region in the United States for launching satellites was centered at Vandenberg Air Force Base. Now there is a facility for firing the Scout rocket at Wallops Island in Virginia, where the Shotput inflation tests (for the Echo balloons) were carried out. A Scout launching tower has been constructed, having a boom for erecting the first two stages, and platforms for upper-stage installations and checkouts.

Unlike its liquid-fuel cousins, Scout is ordinarily tipped a few degrees from the vertical when it is fired, being launched directly from the boom on the tower. The entire rocket assembly is about 72 feet long and weighs 18.3 tons. Another NASA facility in Virginia, Langley Research Center, supervised development of the system. Each stage is derived from earlier solid-fuel rockets and is named for a bright star.

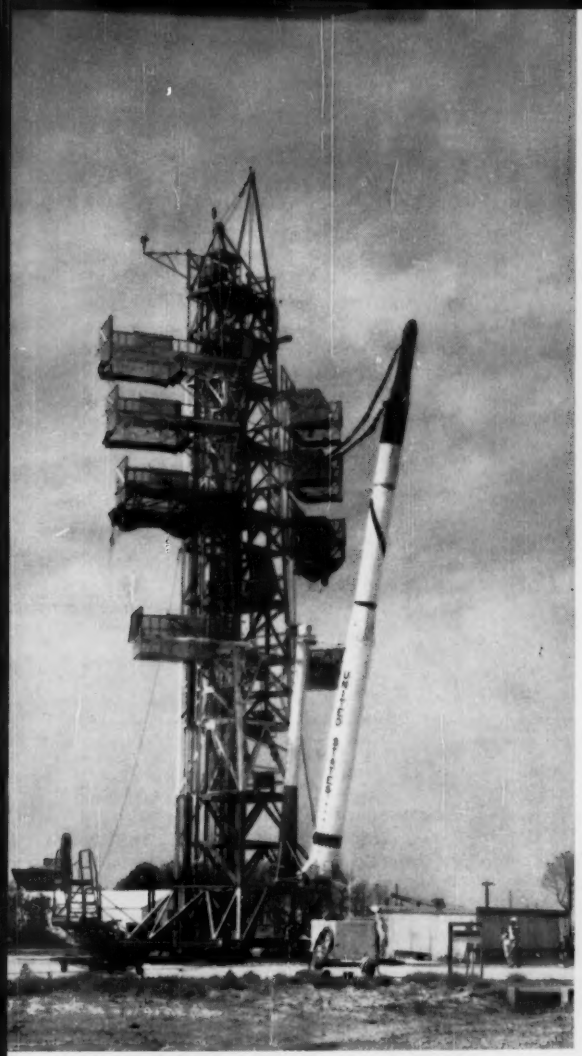
Algol, the first stage, stands some 30 feet high and is 40 inches in diameter. It is our largest operational solid-fuel missile, an adaptation of a test unit originally designed for the Polaris program. Four fins at the base of Algol stabilize the initial phase of the flight. The firing orientation is controlled by servo-mechanical adjustment of four molybdenum vanes immersed in the rushing stream of hot exhaust gases. These 36-pound deflectors measure less than nine by nine inches; of course, they are effective only during powered flight, which lasts 44 seconds at about 115,000 pounds of thrust. During the 25-second coasting period that typically follows immediately thereafter, the flight orientation is controlled by four hinged tips of the vehicle's fins.

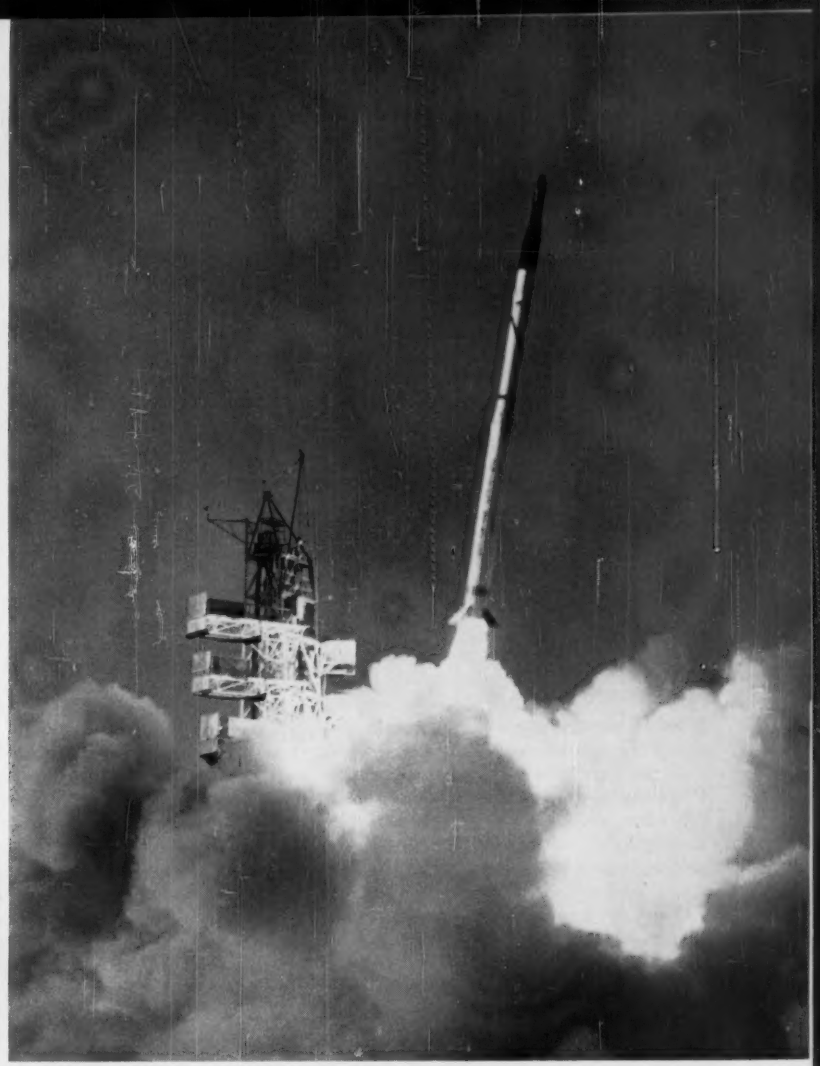
When the second stage, called Castor, fires, the empty Algol casing is blasted away. Castor is an enlarged Sergeant rocket, 20 feet by 30 inches, which for a 41-second burning time gives 50,000 pounds of thrust. Its flight is stabilized by hydrogen peroxide jets that develop 600 pounds briefly for orienting the vehicle in pitch and yaw; small jets control roll.

Antares, the third stage, is a 10-foot by 30-inch enlargement of the fourth stage, Altair. When the former ignites, usually after five seconds of coasting, the second stage and the aerodynamic shields fall away. During the next 40 seconds, Antares



Technicians at Langley Research Center test the instruments and guidance controls on the four-stage Scout satellite launcher. Its payload, the Baby Echo balloon, may be seen tightly folded in its canister at the right-hand end of the rocket complex. The four stages are individually transported to the launching site, where final assembly takes place.





These pictures show the first and third Scout vehicles to be tested. Prior to firing, the Scout stands erect in its tower, surrounded by the swinging platforms which provide access to its higher stages. At launching, the boom supports the rocket at an angle of about five degrees, as shown at the left. Clouds of smoke accompany the firing (right). All pictures with this article are courtesy National Aeronautics and Space Administration.

produces about 13,600 pounds of thrust, while hydrogen peroxide jets control its orientation. Some of the jets are very tiny and operate when there is a long coasting period after burnout. In a typical orbital shot, this phase may exceed seven minutes.

The guidance package for the entire vehicle is carried in the upper end of the third stage. It includes gyros, accelerometers, timers, and a preset programmer that chiefly determines the pitch angle at which each step in the chain of events is conducted.

After the coasting period, three small rockets fastened to a turntable cause the fourth stage and payload to rotate about 160 times a minute. Then the Altair, a six-foot by 18-inch rocket, fires to provide the final acceleration, for 44 seconds at 3,000 pounds of thrust. This solid-fuel motor was known earlier as the X-248. Originally designed to be the third stage of Vanguard, it was later used in the Able vehicle and still is a part of the Delta configuration. Lightweight plastic is used throughout its construction.

The entire Scout assembly has been launched only three times. On July 1, 1960, in a high-trajectory shot, ignition of Altair was prevented by ground command of the range safety officer, partly as a result of an erroneous radar indication that the vehicle had veered off course.

On October 4th last year, the first successful four-stage flight carried as high as 3,500 miles, and engineering data were obtained. The first orbital attempt, on December 4, 1960, ended in failure when the second stage did not ignite. The same kind of payload is being readied for a similar attempt, scheduled for mid-February.

The Scout Research Program

WHILE the next few Scout launchings will be made chiefly to test vehicle performance, scientific payloads will also be carried. A 12-foot inflatable balloon, inevitably dubbed Baby Echo, is presently planned for the next orbital attempt. Twice in earlier programs, and once before in the Scout series, there have been unsuccessful efforts to launch balloons of this size in order to obtain improved atmospheric drag measurements.

When the density of the upper air is to be inferred from the rate of change of a satellite's period, a spherical shape is advantageous, for the drag effect is the same regardless of how the satellite turns in space. A balloon offers the further gain of having both very light weight (14 pounds in this case) and large cross section. Its orbital period will be highly sensitive to the atmosphere's density near its perigee, which is expected to be initially about 410 miles. At the planned apogee of around 1,270 miles, the drag effect will be insignificant in comparison.

For rigidity, the balloon is being made of two 0.0005-inch Mylar layers alternately laminated with two aluminum sheets of the same thickness. The added stiffness requires an ejection bellows to release the balloon from its canister, and a small tank of nitrogen is needed to produce a temporary inflating pressure of about half a pound per square inch.

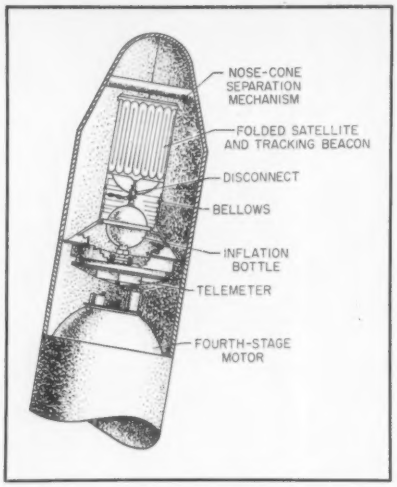
Four groups of solar cells, each of 70 units, are arranged on the balloon's surface at the corners of a tetrahedron, to

collect energy for miniature storage batteries and a radio inside the satellite. The antenna for this tracking transmitter was made by dividing the aluminum foil into two hemispheres. Fifteen milliwatts of power will be continuously broadcast at the new Minitrack frequency, 136 megacycles.

About a sixth of the area of the outer aluminum skin is covered by polka dots of white epoxy paint. The purpose of this pattern is to control the temperature of the interior. Inasmuch as a 12-foot specular sphere reflects the sun from a spot only 0.3 inch in diameter, ground observers may see unusual variations of the satellite's brightness. Sometimes the sun's entire specular reflection will be masked by a one- or two-inch painted spot, and only the faint scattered light from many other polka dots will reach the observer. These moments of relative darkness will alternate quasi-periodically with sustained bright flashes, at a rate determined by the balloon's rotation and other geometric factors. Photographs may well show this effect.

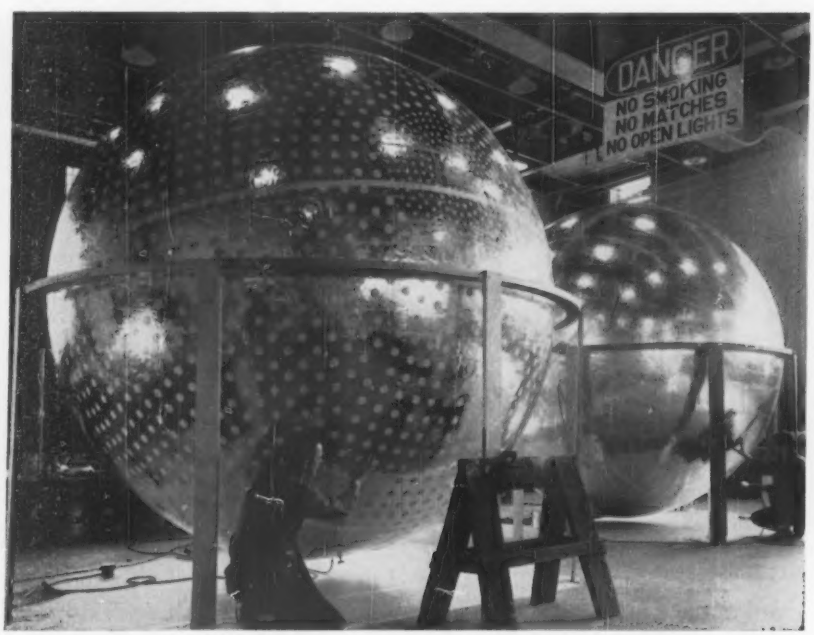
If the intended orbit is attained, the 12-foot sphere will brighten to magnitude 2.9 when closest to a ground observer, and fade to magnitude 7.5 when seen near the horizon at apogee — provided the specular reflectivity is 80 per cent.

Another Scout payload soon to be launched should provide information on the penetration of structures by meteorites. Beer-can-size pressurized chambers, 160 in number, and other types of meteorite detectors will be compared. Also, high-altitude measurements of electron density are being planned.



This sketch shows how a 12-foot balloon, such as one of those pictured below, and its associated equipment are packed in the nose section of the Scout rocket. When placed in orbit, changes in the balloon's motion around the earth will be used for calculating upper-air densities.

Perhaps a year from now payloads designed by other nations (Canada, Great Britain, Japan) will be carried aloft by American boosters, including the Scout. Various polar-orbiting flights are being considered. The Air Force has adopted the basic Scout vehicle for a program called Hyper-Environmental Test System 609A, in which engineering data for future missions will be acquired. These launchings, some of them orbital attempts, will be made from Cape Canaveral.



These are two of the Mylar-aluminum balloons that are to be launched by the Scout solid-fuel rocket from Wallops Island, Virginia. Two sizes of epoxy-paint polka dots for temperature control have been applied to the nearer sphere. An insulating divider girdles the sphere above the stand.

Samos II

ON JANUARY 31st at about 20:35 Universal time, the U. S. Air Force launched an experimental satellite in the Project Samos series, whose purpose is the testing of reconnaissance-instrument components. This first successful shot used an Atlas-Agena combination and was made from the Naval Missile Facility, Point Arguello, California, adjacent to Vandenberg Air Force Base. The firing took place on the evening of the third anniversary of the United States' first successful satellite launching — Explorer I.

Samos II has received the designation 1961α. According to early information released by the Air Force's ballistic missile division, it is traveling in a near-polar orbit with perigee and apogee heights of 300 and 350 miles, respectively, and a revolution period of about 95 minutes.

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F. J. M. STRATTON

An English astrophysicist who was an outstanding organizer of international cooperation in astronomy, F. J. M. Stratton died last September 2nd at the age of 78. A native of Birmingham, he had a brilliant career as a student at Cambridge University and later as professor of astrophysics there and director of its solar observatory.

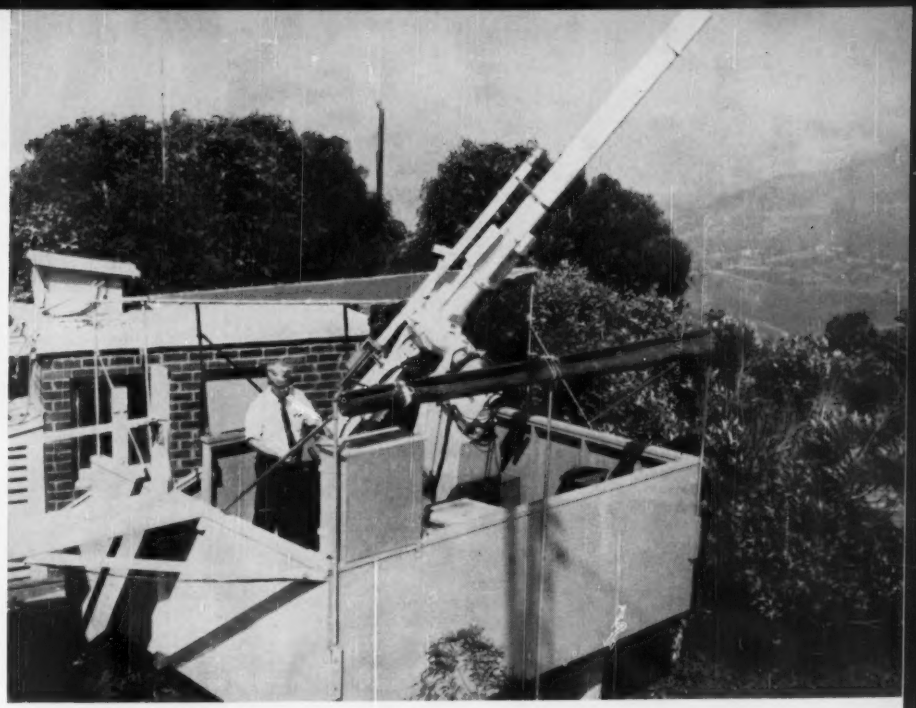
Nova spectra had a particular fascination for him. His pioneer investigation of the spectrum of Nova Geminorum 1912 began a series of publications that added greatly to knowledge of these extraordinary stars. Stratton was among the first to apply modern physics to the interpretation of astronomical spectra. His book, *Astronomical Physics,* which appeared in 1925, provided a lucid and concise guide for a generation of astrophysicists. One indication of his scientific stature is the fact that the first two volumes of *Vistas in Astronomy* (1955, 1956) were prepared in his honor.

Stratton was secretary of the International Astronomical Union from 1925 to 1935, his efforts contributing greatly to the growth and effectiveness of this world organization. The secretaryship was only one of the many honors that came to him. He was also president of the Royal Astronomical Society, a fellow of the Royal Society, and general secretary of the International Council of Scientific Unions for 15 years beginning in 1937. During World War I he was a lieutenant colonel in the Royal Engineers, winning the Distinguished Service Order, and in 1940-45 served in the Royal Corps of Signals.

The last large-scale meeting that Dr. Stratton attended was the Moscow gathering of the IAU in 1958, when he was 76 years old. A picture of him taken there is on page 165 of this issue.

Fast-Moving Disturbances on the Sun

G. E. MORETON, *Solar Observatory, Lockheed Aircraft Corporation*



Lockheed Solar Observatory, 1,500 feet above sea level, uses the original Climax 3-inch coronagraph, lent by High Altitude Observatory. The photoelectric guidance system is located above the main tube. An open-air platform, with a ventilated floor, minimizes convection currents. All photographs with this article are from Lockheed Aircraft Corp., Burbank, California.

TWO YEARS AGO Lockheed opened a solar observing station in the Hollywood Hills section of Los Angeles, California. There the sun is continually photographed to record solar flares and related phenomena. Exposures are made at 10-second intervals. An excellent observing environment is provided by the same condition causing local smog; the temperature inversion that caps the Los Angeles basin and inhibits air flow provides a stable atmosphere. The freedom from convection results in prolonged periods of good seeing.

The pictures are taken in red light, through a birefringent filter that transmits a half-angstrom band at the wave length of the hydrogen-alpha line in the solar spectrum. Chromospheric features such as flares, prominences, and filaments (prominences seen in absorption against the solar disk) are not visible in an ordinary telescope because of their faintness in relation to the intense radiation of the photosphere. The narrow-band filter excludes this bright background and allows detection of those features radiating hydrogen light. Operating in the long wave length region of the spectrum, combined with the narrow passband, also significantly reduces light scattered by smog particles.

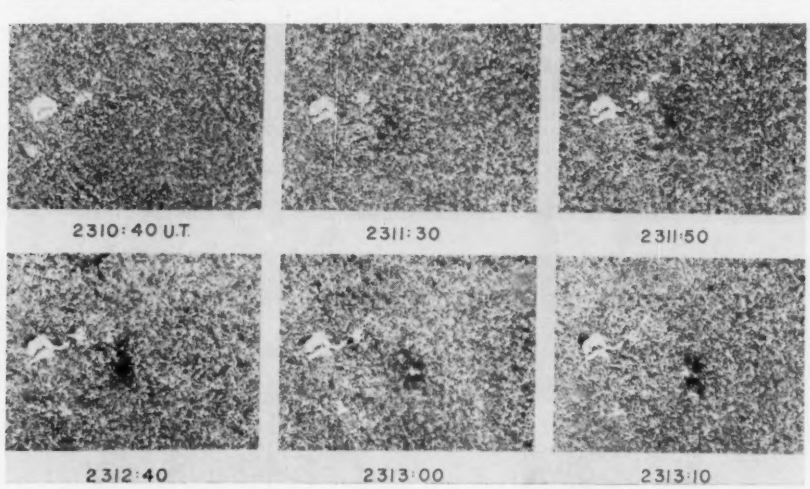
The solar image, 0.7 inch across, is photographed on 200-foot lengths of special 35-mm. film. Each roll of the time-lapse film contains about 3,100 solar images. For routine inspection and measurement of the negatives, we use a film viewer that magnifies the solar disk to 11 inches in diameter. Unusual events noticed in the inspection are prepared for further study by copying the record on 16-mm. positive film and projecting it to give a five-foot image. Viewed at about 25 frames per second, this film reveals interesting changes in flares, and has enabled us to detect fast, faint motions that often cannot be recognized by routine scanning of the original negatives.

The most significant result of our research has been the detection of extensive wavelike disturbances directly initiated by solar flares. In 11 events studied to date, these disturbances propagate over great distances across the solar disk, with average speeds of about 1,000 kilometers per second.

The flares triggering such disturbances show a distinct "explosive" development. Following the initial brightening, the intensity increases sharply, and the luminous borders expand outward at several hundred kilometers per second.

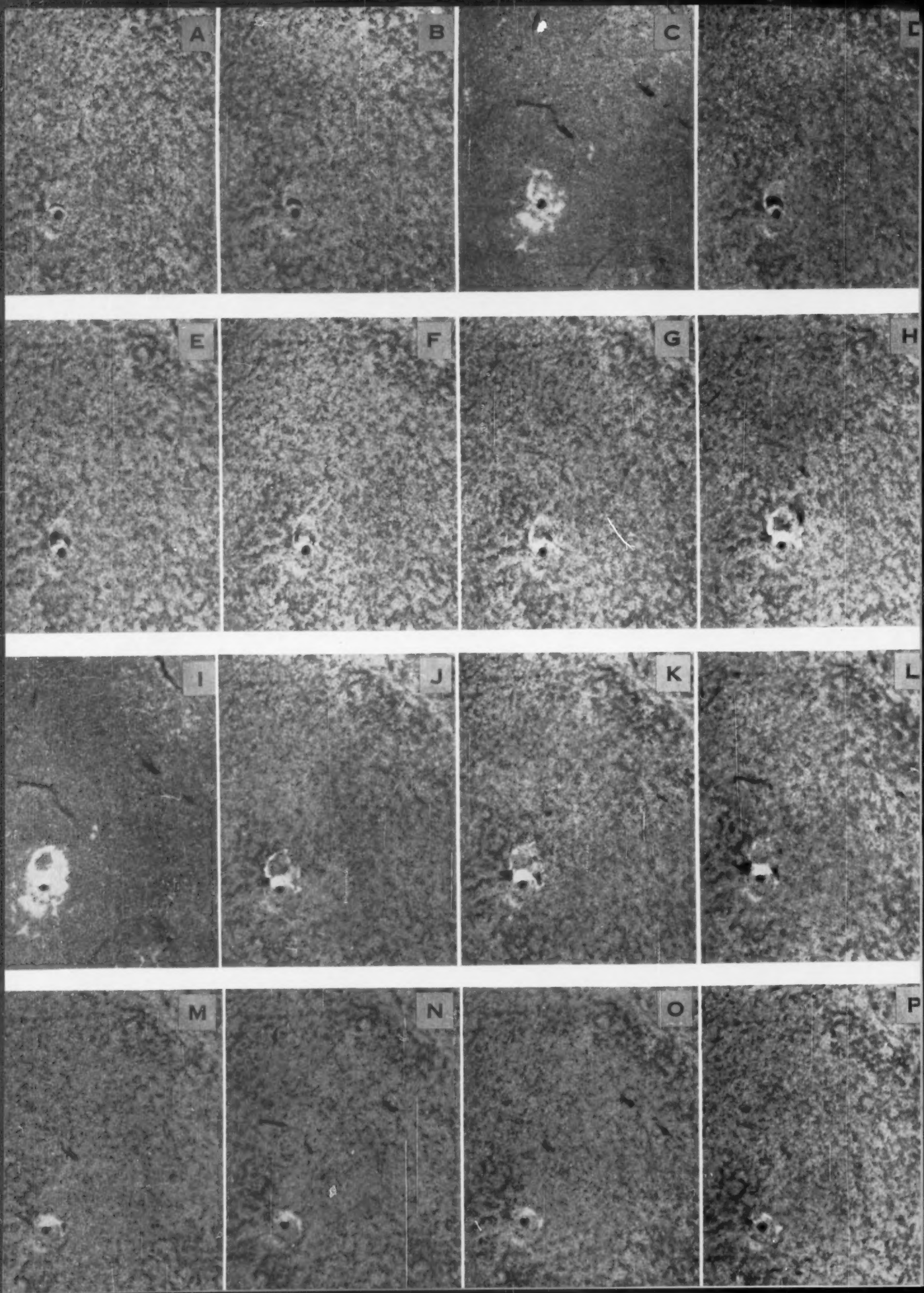
As a direct consequence, distant filaments, often as far as 600,000 to 700,000 kilometers from the flare site, undergo temporary fading or disappearance. Outstanding examples of such activation occurred on July 15-16, 1959.[1] A large, apparently stable filament abruptly began to change, was completely invisible for less than two minutes and then, just as suddenly, reappeared in its original form. The filament underwent this change on two occasions, both following an explosive flare.

The rapid time-lapse photography allows us to time filament changes and the sharp onset of the explosive phase to within ±10 seconds. The distance from the flare to the filament, divided by the time interval between the explosive phase and the activation, yields an average speed for the traveling disturbance. The rates of propagation found in this way



A high-speed disturbance racing across the face of the sun was associated with a September 7, 1960, flare. These prints, on a scale of about 105,000 kilometers per centimeter, were made by superimposing previously exposed positives over negatives of the flare to accentuate moving features.

[1] R. Grant Athay, *Science, 132,* 707, 1960.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are consistently about 1,000 kilometers per second.

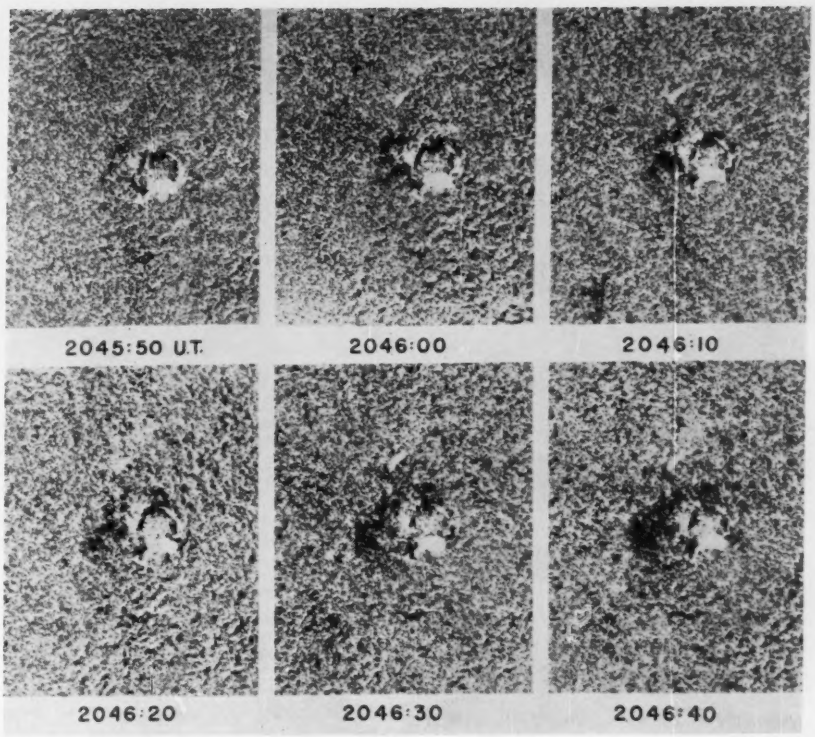
Since January, 1960, routine observations have been made with the filter passband displaced about 0.5 angstrom from the Hα-line center. As the flare-disturbance activates the filament, random Doppler shifts broaden the line profile. These changes in the width give increased contrast between the absorption feature and the disk background. Also, direct detection of the disturbance is aided by the random motions within it, or by turbulence in the chromospheric background as the disturbance passes.

These techniques have resulted in the first direct photographs of the broad, wavelike disturbances directly initiated by explosive flares. The velocities of the disturbances, previously inferred from filament activations, are confirmed by our direct measurements.

The most noteworthy event occurred June 25, 1960, and is seen in the series of pictures on the facing page. They were selected from 360 exposures made during a one-hour period. Slow expansion of an absorption feature that preceded the flare is shown in **A, B, D, E.** The absorption feature was not visible at the Hα-line center, as seen in **C.** The flare itself, of importance 2+, begins at 20:39 Universal time, between **B** and **C.** The main flare-disturbance starts to spread from the flare at 20:45:40, and is faintly visible as a slight background change on **J.** The pictures on this page, taken at 10-second intervals beginning 20:45:50, reveal the feature's quick development. This set was made by superimposing a positive enlargement taken prior to the flare over negative enlargements made at the times shown. Any static formations in the field should be nearly canceled out by this technique, accentuating markings that have moved or altered in appearance.

Later, in the full-page series, the sudden activation of distant dark filaments is quite evident. Filaments in one frame are weak or invisible in preceding and following frames, for example, **M** and **N.** At least six filaments were activated during this complex event. Some underwent change more than once, suggesting the passage of slower components of the main disturbance.

FACING PICTURE: A portion of the sun, seen in light from the wing of the hydrogen-alpha line, shows events associated with flare activity around a small sunspot on June 25, 1960. As a disturbance travels outward from the flare, it causes filaments at great distances to become temporarily darker. The Universal times follow: A. 20:27:30 B. 20:37:00 C. 20:40:00 D. 20:40:10 E. 20:42:40 F. 20:43:00 G. 20:44:00 H. 20:45:20 I. 20:46:00 J. 20:46:10 K. 20:47:40 L. 20:50:00 M. 20:53:40 N. 20:57:00 O. 21:03:20 P. 21:13:00. Frames C and I show the region's appearance at the center of the hydrogen-alpha line. In these pictures, one centimeter corresponds to about 90,000 kilometers.



Universal times are marked on these positive-negative prints of a flare on June 25, 1960. The scale is about 100,000 kilometers per centimeter.

Still photographs give only a hint of the true extent of the event. When viewed by ciné projection, features not noticeable on single frames become easily visible by virtue of their motion. In the case of this event, projection reveals a broad diffuse cloud, slightly darker than the chromospheric background, that erupted over one-half of a solar radius. Direct measurements by 16-mm. projection confirm the velocities that had been found by timing the filament activations. One element of the disturbance has a velocity of more than 2,500 kilometers per second.

The prints on page 145 show another well-observed event on September 7, 1960, with the onset marked by an explosive flare of importance 1+. The spreading of the feature outward from the flare is obvious. Measurements yield a velocity of 1,100 kilometers per second, with an uncertainty of 50.

Interpretation of these remarkable phenomena provides an interesting problem for solar investigators. Our observations do not allow a direct distinction to be made between a moving cloud of material and a traveling disturbance such as a shock wave. However, the following evidence is offered in favor of the particle-cloud concept:

1. The observed disturbances move in well-defined directions, suggesting a plasma cloud guided by local magnetic fields.
2. Geomagnetic storms, aurorae, and slow-drift solar radio bursts are thought to be caused by flare-ejected particle clouds. The velocities of these clouds, inferred by a variety of indirect methods, are of the same magnitude as these new flare-initiated features.
3. R. Grant Athay, of the High Altitude Observatory, and the author have devised a theoretical explanation for the abrupt change and disappearance of filaments.[2] Our theory, in which a discrete cloud of solar plasma impinges on the filaments, fits the observations quantitatively as well as qualitatively.
4. In some cases the flare disturbance appears to avoid or be deflected by small bright patches in the chromospheric background (see the September 7th picture at 23:13:00). J. M. Malville, High Altitude Observatory, suggests that such patches may be areas of strong magnetic-field intensity,[3] in which case the observed deflection could be an ionized cloud reflected by these regions.

These new observations may represent the first direct evidence of solar corpuscular streams, and may be of importance in interpreting solar and solar-terrestrial phenomena.

[2] R. Grant Athay and G. E. Moreton, *Astrophysical Journal,* in press.

[3] J. M. Malville and G. E. Moreton, *Nature,* in press.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 107th meeting of the American Astronomical Society at New York City, December 28-31, 1960. Technical abstracts will appear in the Astronomical Journal.

First True Radio Star?

In an unscheduled paper, Allan R. Sandage, Mount Wilson and Palomar Observatories, described a 16th-magnitude object in Triangulum that appears to be the first case where strong radio emission originates from an optically observed star. It was found in the course of the survey now being conducted at the radio observatory of California Institute of Technology to obtain very precise positions of radio sources. Twin 90-foot parabolic antennas, movable to various positions along a huge cross formed by a pair of tracks, are used for this work.

Thomas A. Matthews first determined a six-times more accurate position for the source 3C-48 than had hitherto been established at Cambridge University in England. The world's largest steerable paraboloid, the Jodrell Bank 250-foot radio telescope, had set the source's diameter at less than four seconds of arc.

At 96 megacycles, the Caltech instruments gave a radio flux intensity of 21.3×10^{-26} watt per square meter per cycle per second, while in England values of 50 and 43 were found at 159 and 178 megacycles, respectively. So strong a flux from such a small area led Dr. Matthews to suggest that the 200-inch telescope be used to search for an optical object in the same place in the sky.

Dr. Sandage, in a recent 90-minute exposure, found a star at the precise position. It is accompanied by a faintly luminous nebulosity measuring about five by 12 seconds of arc. The star is at right ascension $1^h\ 34^m\ 51^s$, declination $+32°\ 54'.2$ (1950 co-ordinates), just where the radio source is located, so there is practically no doubt that the two are the same.

Spectrograms taken by Jesse L. Greenstein and Guido Munch of Caltech, and by Dr. Sandage, show a combination of strong emission and absorption lines unlike that of any other star known. The star or its gaseous envelope contains ionized calcium, ionized and neutral helium, and possibly oxygen ionized many times. The spectrum shows no hydrogen, the main constituent of all normal stars.

Since the distance of 3C-48 is unknown, there is a remote possibility that it may be a very distant galaxy of stars; but there is general agreement among the astronomers concerned that it is a relatively nearby star with most peculiar properties. It could be a supernova remnant. The radio output may be intrinsically 10 million times stronger than the sun's.

If the star were surrounded by high-energy electrons traveling in a magnetic field at near the velocity of light, the resulting synchrotron radiation would produce both its light and the radio energy. Despite its yellow color, the star is unusually bright in the ultraviolet region of the spectrum, an indication of synchrotron radiation.

Radio Observations of a Planetary Nebula

During the past four years, several observatories have attempted to detect radio emission from planetary nebulae. The first definite success was recently achieved by University of Michigan astronomers A. H. Barrett, W. E. Howard, and F. T. Haddock, in measuring radiation from NGC 6543. This planetary, at right ascension $17^h\ 58^m.8$, declination $+66°\ 38'$ (1950 co-ordinates), is one of the brightest in the sky and remarkable for its seemingly helical structure.

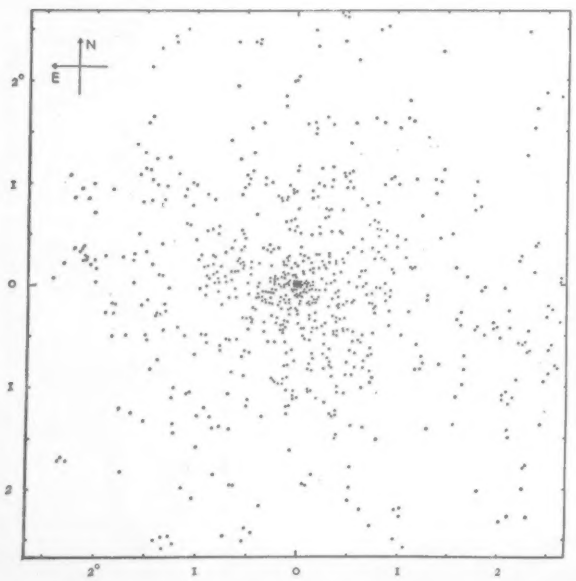
For their 3.45-centimeter (8,700 megacycles per second) measurements, the Michigan team used the 85-foot Portage Lake radio telescope equipped with a ruby maser developed by M. E. Bair, J. J. Cook, and L. G. Cross. On two occasions the nebula was observed by the drift-curve method, in which the antenna was pointed just west of the object, which was then allowed to drift through the antenna beam. On two other dates, the antenna was alternately pointed toward the nebula and away from it.

These observations demonstrated the existence of a radio source agreeing in position with the nebula, and having dimensions considerably smaller than the antenna beam-width of 6½ minutes of arc. A radio flux of 4.0×10^{-27} watt per square meter per cycle per second was indicated by the antenna temperature of 0.034° Kelvin.

This is a considerably weaker source than predicted. From the properties of NGC 6543, determined by optical observations, the Michigan astronomers had computed an expected antenna temperature of 0.074° K. A second calculation, based on data furnished by Donald E. Osterbrock, gave 0.135° K. Both predictions depend on an idealized model of the planetary, whose assumed distance of 1,100 parsecs is uncertain.

Recently Thomas A. Matthews has observed NGC 6543 at a wave length of 31.2 centimeters, using a 90-foot telescope of California Institute of Technology. He finds an antenna temperature consistent with the Osterbrock prediction.

On the other hand, microwave measurements of NGC 6543 that agree with the Michigan results have been made by Roger Lynds at the National Radio Astronomy Observatory.



The tendency of the members of the Coma cluster to be irregularly distributed is shown in this plot by F. Zwicky. In the central part, the average distance between galaxies is only about a tenth as great as in the general field of the sky around the cluster. Taken from the "Astrophysical Journal."

Clustering of Galaxies

Photographs taken with wide-angle telescopes show that the distribution of galaxies over the sky is distinctly non-uniform. Most astronomers believe that this is due to a tendency of galaxies to occur in clusters. This belief was critically weighed in a paper presented by Sidney van den Bergh, David Dunlap Observatory, University of Toronto.

He raised the question: Is a cluster of galaxies an indivisible unit, or divisible into subclusters? Furthermore, are clusters of galaxies the largest aggregations of

matter, or parts of still larger organizations?

Several lines of evidence against the clusters being basic units were advanced by the Canadian astronomer. He first called attention to the local group of galaxies (including our Milky Way, the Magellanic Clouds, the great spirals M31 and M33, and a dozen or more nearby systems). Often the local group has been regarded as forming a small cluster, but its members tend to occur in clumps of twos and threes, indicating subsystems.

Dr. van den Bergh also pointed out that the surface distribution of galaxies in the famous Virgo cluster is quite irregular. His recent study of radial velocities in the Virgo cluster shows that it contains stable binary and multiple systems.

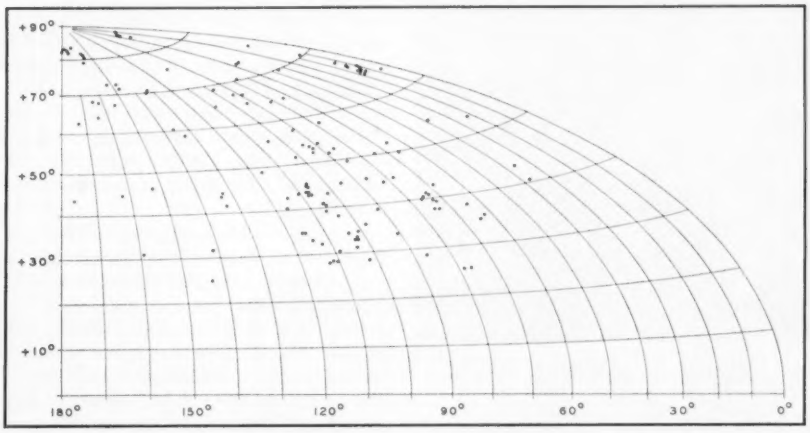
Another well-known cluster of galaxies, that in Coma, seems to have a rather smooth structure, on a simple examination of photographs. But Dr. van den Bergh has applied a more searching test. On pictures taken with the 48-inch Palomar Schmidt telescope, he measured the apparent separations among more than 100 galaxies near the core of the Coma system. Then he made similar measurements for a synthetic cluster whose members had the same radial distribution as in the Coma cluster, but whose directions from the center were purely random.

The test showed that small projected separations were more frequent in the actual cluster than in the synthetic one. This result implies that subclusters occur in the Coma system. They would be at least 225,000 light-years across, if the distance is of the order of 200 million light-years. However, as Dr. van den Bergh comments, this apparent subclustering might also be due to an incorrect choice for the cluster center, or to the existence of one or more small background clusters.

Although the Coma cluster seems to be an isolated unit, there is growing evidence that the clusters in general are not randomly spread over the sky, but have a tendency toward clumping. In 1958, George O. Abell, University of California, studied the distribution of 2,712 clusters of galaxies, demonstrating the existence of superclusters. At Lick Observatory, C. D. Shane and C. A. Wirtanen compiled contour maps from their counts of galaxies, showing many clouds consisting of one or more major clusters surrounded by lesser ones.

This Lick Observatory contour map indicates galaxy distribution in parts of Serpens, Bootes, and Virgo. The cloud at the upper left contains over 1,200 counted members in 20 square degrees; below center is a complex of 2,800.

In the sky chart below, the Canadian astronomer has plotted the rich clusters from the Abell catalogue that are so distant their red shifts approximate 50,000 kilometers per second. The arrangement is distinctly nonuniform, and inhomogeneities as large as 20 degrees in angular size are indicated. This pattern is not due to patchy absorbing clouds within our own Milky Way masking distant galaxies, Dr. van den Bergh argues. For example, the richest areas do not coincide with those in plots of somewhat less distant clusters. He therefore believes that the indications of superclusters are real and not merely apparent.



The galactic longitudes and latitudes of rich and very distant clusters of galaxies have been plotted here by Sidney van den Bergh, from data by George O. Abell. Below latitude +25° Milky Way dust clouds affect the counts.

Water Vapor on Mars

All spectroscopic searches for water vapor in the atmosphere of Mars have been negative, and lead to the conclusion that there cannot be more than 0.035 gram of water above each square centimeter of the planet's surface. Carl Sagan, of the University of California, reported recent calculations on the problem.

It has long been known that the observed surface temperature of Mars is about 30 degrees centigrade higher than would result from the sun shining on an airless planet at its distance. The amount of this greenhouse effect depends on the abundance of carbon dioxide and water vapor in the Martian atmosphere, and upon the infrared emissivity of the surface. Since the quantity of carbon dioxide is known from observation, and since the emissivity can be estimated within narrow limits, Dr. Sagan deduced that there is between 0.02 and 0.002 gram of water over each square centimeter.

He was able to make a second evaluation from the vapor pressure of water at the edges of the polar caps, where ice is subliming to vapor. This method gives about 0.01 gram per unit area.

Dr. Sagan concludes that the Martian water vapor could be measured directly if the sensitivity of present infrared spectroscopic methods were improved about 10 times, which might be possible if the observations were made high above the earth's surface.

He points out that such very low water vapor contents do not preclude life on Mars. There are terrestrial organisms (obligate halophiles) that fill their entire H_2O requirements from the moisture that collects on a crystal of salt.

GETTING ACQUAINTED WITH ASTRONOMY

THE ASTEROIDS

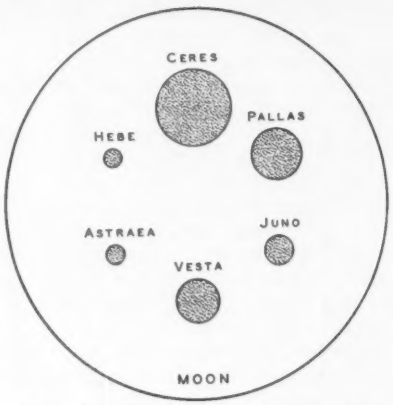
AT OBSERVATORIES where long-exposure sky photographs are taken with large, wide-field telescopes, the negatives often show one or more short black lines amidst the host of round star images. These are trails of minor planets or asteroids, whose motion during an exposure of several hours has caused their images to be elongated.

Like the nine principal planets, the asteroids are in orbital motion around the sun; most of them follow paths between those of Mars and Jupiter, with periods of the order of four or five years. But 944 Hidalgo, when farthest from the sun, is as remote as Saturn, while 1566 Icarus at perihelion comes well inside the orbit of Mercury. Most of the asteroids have orbits more strongly elliptical than those of the principal planets, and with higher inclinations to the central plane of the solar system.

The minor planets are diminutive bodies. The largest, 1 Ceres, one of the very few that show disks in even the largest telescopes, is only about 460 miles in diameter. Some recent discoveries, characterized as "mountains torn loose," are less than a mile in diameter. The total number of asteroids is enormous, nearly 100,000 being bright enough to be photographed with the 100-inch Mount Wilson reflector. However, a scant 1,600 or so have been thoroughly enough observed to permit reliable orbit calculations, from which positions can be predicted several years in advance. Only members of this select group have been assigned individual names and serial numbers.

Photoelectric measurements have shown that many minor planets undergo small brightness oscillations, with periods of a few hours. Evidently these are irregularly shaped bodies in rapid axial rotation. In general, this variability is too small to be conveniently studied by visual methods, but 433 Eros sometimes changes as much as two magnitudes as it rotates. In 1931, when Eros passed only 16 million miles from the earth, its elongated shape was seen by W. van den Bos and W. Finsen with the 26-inch refractor of Union Observatory in South Africa. The brightness changes of Eros will be an interesting subject for observation when this minor planet makes its next close approach to the earth in 1975.

Only one of the asteroids, 4 Vesta, becomes bright enough at times to be visible to the unaided eye under ordinary circumstances. For example, at its opposition last July it attained a visual magnitude of about 5.6. Several dozen can be observed with small amateur telescopes, appearing as starlike objects, identifiable only by their motion or with the aid of suitable star charts. Locating an asteroid from the predictions given in this magazine and tracking it from night to night make an interesting amateur project.

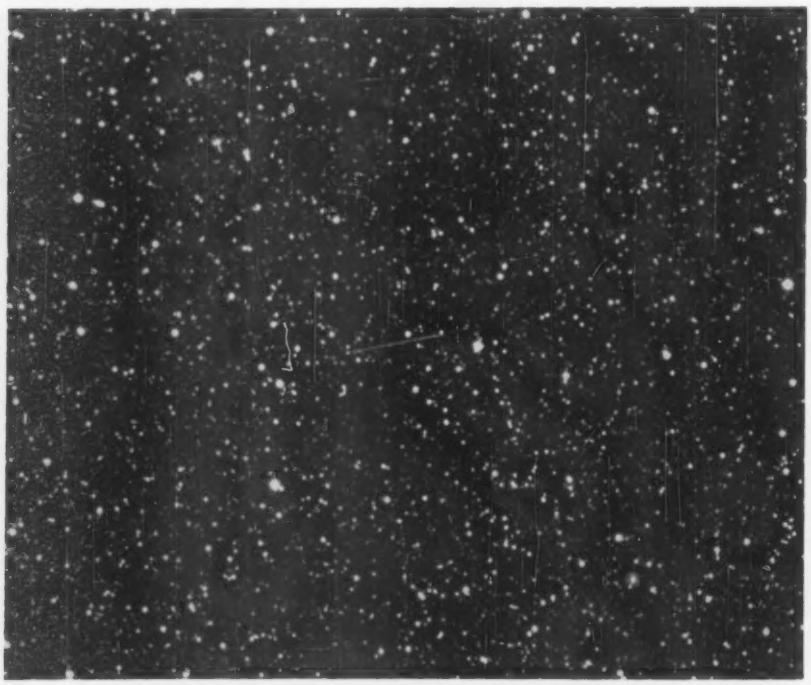


The sizes of the first six asteroids to be discovered are compared with the moon (diameter 2,160 miles). All asteroid dimensions are only approximate, and the sizes of most can be gauged only from their brightnesses.

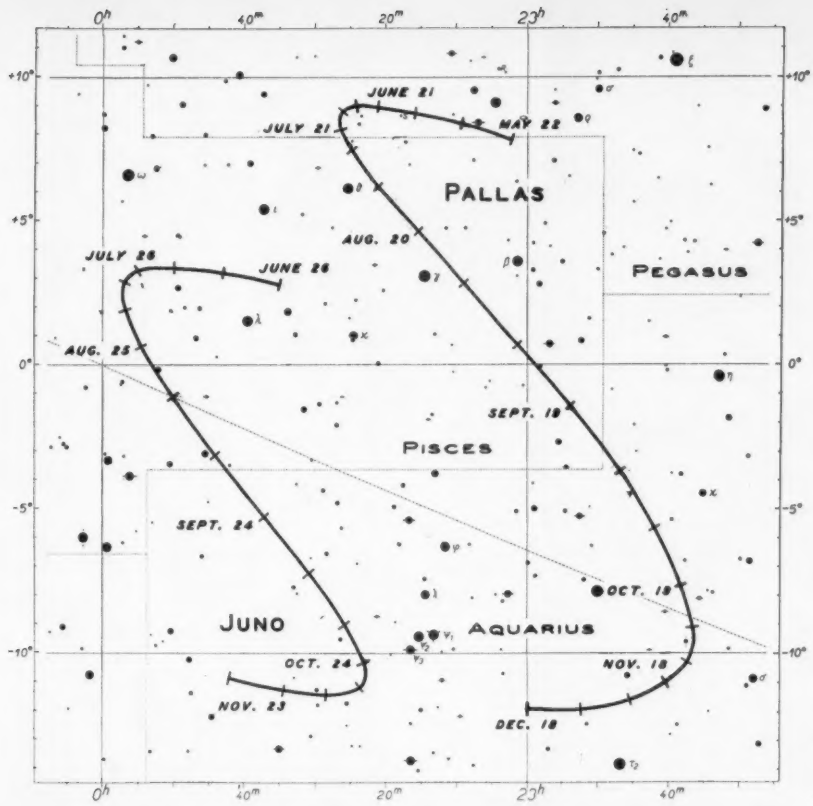
The practical observing problem may be illustrated by the case of Vesta. This asteroid revolves around the sun in an orbit 2.4 times the diameter of the earth's orbit, in a period of 3.6 years. Thus Vesta is much nearer the earth, and hence brighter, around the date of its opposition, when the earth is between the asteroid and the sun, than around the date of conjunction, when Vesta is on the far side of the sun. The average interval from one opposition to the next is 16½ months.

This March 16th, Vesta is in conjunction with the sun, at visual magnitude 8.1. Thereafter the asteroid moves eastward in the morning sky, gradually brightening. On October 1, 1961, when Vesta is magnitude 7.0, its apparent motion changes from eastward (direct) to westward (retrograde), as the earth begins to overtake it. Opposition, at magnitude 6.6, occurs on November 19th, and retrograde motion continues until January 8, 1962, when Vesta, then in the evening sky, resumes its eastward course among the stars. Finally, on July 13th of next year, this minor planet will again be in conjunction with the sun.

The predicted positions of Vesta are published in the *American Ephemeris* for every month, except when the minor planet is too near the sun in the sky. This is also true of Ceres, Juno, and Pallas, which with Vesta were the first asteroids discovered, at the beginning of the 19th century. Because it is so bright, Vesta is easily identified by plotting its ephemeris co-ordinates in a star atlas such as the Skalnate Pleso, which shows all stars as faint as magnitude 7¾.



On June 26, 1949, with the new 48-inch Schmidt telescope of Palomar Observatory, Walter Baade took a one-hour exposure of the sky near Antares. Centered in this eight-times enlargement of his plate is the long trail of a fast-moving body. Later named Icarus, it has the smallest known asteroid orbit, its perihelion distance being only 17 million miles and its aphelion 183 million miles. Mount Wilson and Palomar Observatories photograph. Robert S. Richardson tells Icarus' story in "Sky and Telescope," September, 1949.



The changes in two asteroids' apparent motions, from direct to retrograde and back again, are illustrated here for Pallas (opposition September 7, 1961) and Juno (opposition 11 days later). Their positions at 10-day intervals this year are plotted on the Skalnate Pleso "Atlas of the Heavens."

Fainter asteroids, down to about magnitude 10, can be picked up with the aid of the *Bonner Durchmusterung* atlas. The *Atlas Eclipticalis,* with stars to magnitude 9.0, is also especially useful. Asteroid ephemerides (except for the first four) are usually published only for a month or two before and after opposition, when these objects are brightest and best to observe.

How does the observer locate an asteroid that is fainter than the limit of available charts? When he plots the predicted place on a map, and points his telescope to that place in the heavens, he will see a number of stars, any one of which may be the minor planet. It will be recognizable only by its motion. The average asteroid, near the date of opposition, is retrograding by about 12 minutes of arc per day. This corresponds to a decrease in right ascension about two seconds of time per hour.

A simple micrometer, to be used with an equatorially mounted telescope, is easily made for detecting this drift. It is merely a disk of glass or transparent plastic, marked with a cross heavy enough to be visible against the sky without artificial illumination when it is placed in the focal plane of the telescope. (A white cross can be drawn on black paper and photographed, the film or plate being cut out and fitted into the telescope.)

When this micrometer is used, it is placed so that both cross and stars are simultaneously in sharp focus. The cross is rotated until, after careful trial and error, a star runs along one of its arms when the telescope is stationary. Then the other arm is exactly north and south.

Choose any convenient star in the asteroid's field as a reference object. Then, with the telescope stationary, allow this star and the suspected minor planet to drift behind the north-south arm, determining the time interval between the transits with a stop watch. This gives a measure of the difference in right ascension. Do this for all the stars that might turn out to be the desired asteroid, recording the intervals on a sketch map of the field.

These operations are repeated an hour or two later. If the observations have been carefully made, one of the suspects will reveal itself as the asteroid through a change in its time interval.

Photography can also serve. Asteroid trails are not easy for amateurs to photograph, as an exposure of several hours is required with a long-focus instrument guided with extreme precision. Instead, it is far more convenient to take two shorter exposures a night or two apart. The negatives are then superimposed and searched with a magnifying glass in order to find which image has shifted.

Another procedure is to photograph the star field, with an exposure that will show stars about as faint as the telescope reveals visually, and then make an enlarged print. On a later night, this print can be compared star for star with the sky, and the minor planet will be recognized visually as an interloper in the field.

Hitherto, asteroid observing has been a comparatively neglected amateur activity. Anyone who takes it up may be able to suggest novel methods of study.

LETTERS

Sir:

On page 412 of the May, 1960, issue of SKY AND TELESCOPE, it is stated that a new satellite nomenclature is being recommended by the Committee on Space Research. I gather that all satellites, spacecraft, lunar probes, planetary explorers, and vehicles placed into heliocentric orbits are to receive Greek letter designations.

Rather than merely giving consecutive letters within a year, I would suggest that reference be made to the body around which the man-made probe or satellite finally revolves. Thus, we might have such designations as Terra 1965α, Luna 1965α, Sol 1965α, Mars 1965α, and the like. As the heavens receive more and more earth-launched hardware, this would help us to know quickly what happened to each object.

F. I. ORDWAY, III
3423 Lookout Dr., S. E.
Huntsville, Ala.

Sir:

With great pleasure I have read the very interesting article, "How Can We Detect Radio Transmissions from Distant Planetary Systems?" by Frank D. Drake, in your January, 1960, issue, but with astonishment I noticed my name mentioned.

The article refers to *my* papers concerning the fact that life will thrive only on planets at such distances from their star that the temperature is appropriate. However, the only Polish author of those papers is Dr. J. Gadomski, Warsaw University Observatory. Five of his papers were published in *Urania,* monthly journal of the Polish Amateur Astronomical Society.

I must admit that I am deeply interested in the problem and have often discussed it during my lectures, but I haven't published any papers as yet. I congratulate the United States on Project Ozma and wish it good results.

K. KORDYLEWSKI
University Observatory
Krakow, Poland

ED. NOTE: The addition of Dr. Kordylewski's name was proposed by the editors of SKY AND TELESCOPE and agreed to by the author in the absence of the *Urania* series from the National Radio Astronomy Observatory library. The editor of that journal, A. Wroblewski of Warsaw, also pointed out this error.

NEWS NOTES

STRATOSCOPE II

A remote-controlled 36-inch reflecting telescope will be sent by balloon to altitudes near 80,000 feet late in 1961 by Princeton University Observatory astronomers under the leadership of Martin Schwarzschild. This project, named Stratoscope II, is a sequel to the Stratoscope I ascents in 1957 and 1959, when a 12-inch telescope was used for solar photography from that height (SKY AND TELESCOPE, December, 1959, page 79).

The 4,300-pound flying telescope's 36-inch f/4 primary mirror is constructed of fused silica, to gain insensitivity to temperature changes. A modified Gregorian optical system provides an effective focal length of 300 feet, the image being recorded on 70-mm. film. This telescope is under construction by the Perkin-Elmer Corp., Norwalk, Connecticut. It will have a theoretical resolving power of 1/10 second of arc, sufficient to distinguish two golf balls 15 inches apart at a distance of 500 miles.

When in flight, the telescope assembly, shroud lines, parachute, and balloon will measure over 500 feet high. The balloon itself will be of a new material, known as S-10, which is basically Mylar plastic reinforced with a dacron mesh; it is stronger and lighter than polyethylene. To insure a soft landing for the instruments, a helicopter is to capture the descending balloon and payload before they reach the ground.

Telemetered signals from the telescope will indicate the approximate altitude and azimuth toward which it points, and television cameras will allow ground observers to improve the telescope setting to within one minute of arc. Once this has been achieved, a ground signal will actuate an electronic-optical servo system that will automatically make the precise pointing. Then a ground command will start the telescope's camera.

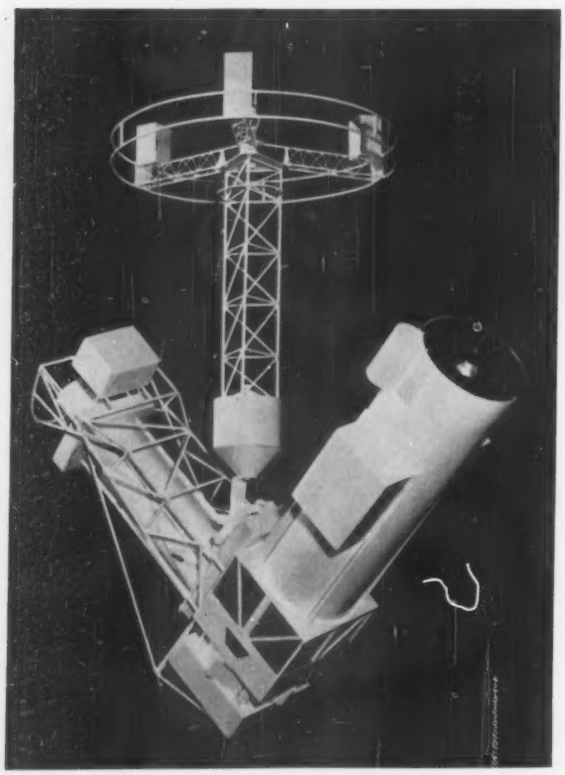
Observing from 80,000 feet, well above the turbulent lower atmosphere, will permit photographs of a sharpness impossible to attain with telescopes at the earth's surface. Among the first Stratoscope II observations planned by the Princeton astronomers is a study of the divisions in Saturn's rings. It is also proposed to investigate changes in the atmospheres of Jupiter and Venus that may be associated with solar activity. Other observations may include photography of gaseous nebulae and the nucleus of the great Andromeda galaxy.

METEORITICS AT ARIZONA STATE UNIVERSITY

The famous meteorite collection of H. H. Nininger, fourth largest in the world, has recently been purchased by Arizona State University, with the aid of a $240,000 grant from the National Science Foundation. The Nininger collection, formerly located at Sedona, Arizona, contains 1,220 catalogued specimens and several thousand small particles from 684 of the 1,600 known meteorite falls. This is approximately 7½ tons of extraterrestrial material.

The new home of the collection is the Nininger Meteorite Laboratory on the campus at Tempe, under the direction of Carleton Moore. The specimens are available for study by scientists, but the collection is not open to the general public.

To mark establishing the laboratory, a symposium on future research in meteoritics will be held the morning of March 10th at the university's life sciences auditorium. Six invited experts on meteorites will speak; their papers, and others to be read by title, will appear in a special publication of the university. Information on the meeting can be obtained from G. A. Boyd, Co-ordinator of Research, Arizona State University, Tempe, Ariz.



A scale model of the 36-inch photographic telescope under construction for Project Stratoscope II. The primary optical system is contained in the 18-foot-long tube at the right, while the 11-foot tube at the left holds the secondary optical system and camera. At the bottom of the larger tube is the f/4 primary mirror; light entering the tube is reflected back to the concave secondary which returns the beam to a flat. This reflects the light up the smaller tube, where it passes through a set of field lenses and then a corrector. Next in the optical path is a two-power lens for photography, which forms the final image on a strip of 70-mm. film. Part of the beam is sent back down the 11-foot tube to the fine-guidance television system. Picture courtesy Perkin-Elmer Corp.

IN THE CURRENT JOURNALS

THE SCIENTIFIC OBJECTIVES OF THE ABLE-5 PROGRAM, by Saul Altshuler, John Lindner, Felix Schweizer, Richard Wagner, and Richard Condon, *Physics Today*, January, 1961. "The ABLE-5 [circumlunar] satellite has been designed as a 390-lb scientific observatory to investigate some important aspects of the physics of space. It contains flux-gate and search-coil magnetometers, a set of radiation sensors, . . . and a micrometeorite counter. The general objective of these sensors is to acquire detailed information about the distribution of magnetic fields, the spectral density of charged particles, and meteoritic statistics."

THE JOHNS HOPKINS UNIVERSITY AND DIFFRACTION GRATINGS, by John Strong, *Journal* of the Optical Society of America, December, 1960. "It is not inappropriate here, at this time . . . to recount some highlights in the history of diffraction gratings. . . . The art, in its main practices, is now mature. This is not to say that there may not be great developments in the future, but gratings of high precision are no longer extremely rare as they were at the beginning of this century."

LIMITATIONS ON SPACE FLIGHT DUE TO COSMIC RADIATIONS, by Howard J. Curtis, *Science*, February 3, 1961. "One of the factors which may severely limit man's operation in space is the presence there of various ionizing radiations. Until very recent years the possibility of putting men in outer space seemed so remote, and the radiations there appeared so weak, that the problem was largely ignored. However, with the development of rocket systems capable of placing satellites in orbit around the earth and with the prospect of placing manned satellites in orbit in the near future, the problem of radiation hazard is both a real and an immediate one."

Amateur Astronomers

An Indiana Amateur's Compact Observatory

IN the past year and a half, my neighbor Forest Coltran and I constructed the eight-foot-square observatory shown here. Built in three parts — foundation, base, and dome — the structure will contain a 10-inch telescope that I hope to have in operation some time before the end of this year.

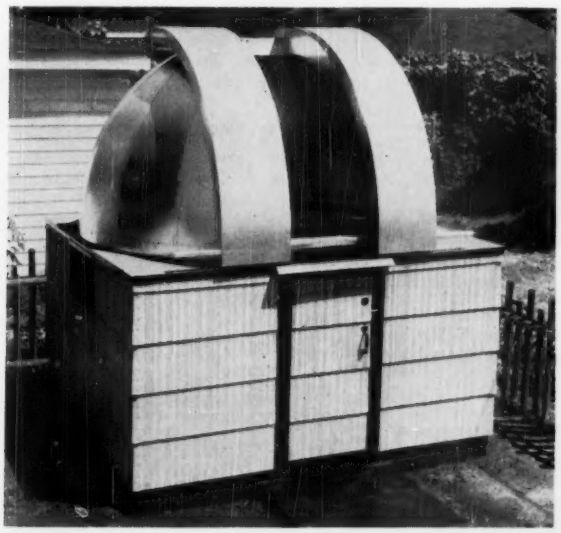
Poured on two levels, the foundation consists of a square eight-foot slab of concrete four inches thick. This is edged with a concrete ridge 4½ inches high and four inches wide. Two outside coats of tar served to seal the joints between the layers. The complete foundation, including a pier one foot in diameter, weighs approximately 1½ tons.

The walls are made of studs carrying ¼-inch exterior fir plywood four feet high. They are sheathed with an arctic white insulation siding, while the top is ¾-inch exterior plywood, protected with valley roofing.

Seventy-eight narrow strips of bowed plywood, lapped alternately and nailed together, constitute the dome. Both it and the double shutters are protected with ⅛-inch tempered composition board, which is highly resistant to abrasion and to temperature and humidity changes. All joints were sealed with bronze weather stripping and caulking, and then the dome received five coats of aluminum paint. The total cost of all building materials came to $305.46.

My sturdy telescope mounting is made from two-inch plumbing pipe, its steel axes revolving in bronze bushings. Counterbalanced by a bar-bell weight, the telescope rests in a 20-inch-long saddle made of varnished oak.

RAYMOND KORUSCHAK
2567 W. 12th Ave.
Gary, Ind.



No space is wasted within Raymond Koruschak's square observatory, as shown below by four pictures of the building's furnishings. Reading clockwise from upper left, the four corners are northwest, northeast, southeast and southwest. A library, study, and storage areas are provided. The exterior view of the observatory, left, shows its sliding double shutters. They and the dome are well sealed with caulking, bronze weather stripping, and aluminum paint. Photographs taken by the author.

NORTH-CENTRAL CONVENTION

The North-Central region of the Astronomical League will convene the weekend of April 28-30 in Urbana, Illinois, under the auspices of the Astronomical Society of the University of Illinois. Convention plans include tours of the university's observatory, radio telescope, and nuclear reactor.

Additional information and forms for registration and for submitting papers can be obtained from regional chairman George E. Kocher, University of Illinois Observatory, Urbana, Ill.

+++ Amateur Briefs +++

The "Celestial Room" on the grounds of the Ft. Wayne Astronomical Society's new observing site is an old trolley bus acquired from the Ft. Wayne, Indiana, transit system. Society members are converting the vehicle into usable space for telescope making, astronomy classes, and star parties.

The Oregon Museum of Science and Industry, Portland, is again sponsoring a Thursday evening mirror grinding class, under the direction of Norman Smale. Amateurs willing to assist in teaching the class are welcome.

A free map of the moon is available for the asking from Aero-Space Laboratories, Missile Division, North American Aviation, Inc., Downey, Calif. The map was prepared by Drs. Dinsmore Alter and Jack Green.

January 31, 1961, was the 25th anniversary of the founding of the telescope making section in the Amateur Astronomers of the Franklin Institute, Philadelphia. Members celebrated the event with a reunion dinner and meeting.

Several younger members of the Astronomical Society of South Australia, Adelaide, are co-operating with the Salvation Army in giving star parties for youth groups.

Auctioning of used telescope parts, optics, electronic gear, clocks, and motors sparked a recent meeting of the Denver Astronomical Society. Proceeds from the equipment donated to the club went into its treasury; but members could also put their own parts on the block, paying a small commission. Between bouts with

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the auctioneer, buyers were scheduled to observe Mars through the Chamberlin Observatory's 20-inch refractor or warm themselves with coffee and doughnuts.

"Project Bright Eye" is the name of a program designed to interest San Antonio, Texas, high school students in astronomy and United States space efforts. Sponsored jointly by Trinity University and Southern Precision Instrument Co., this activity has attracted at least 200 enthusiastic satellite watchers.

As usual, the annual winter weekend of the Amateur Astronomers Association of New York City occasioned a trip to Blue Mountain, Peekskill, New York, where hiking, ice skating, sharing telescopes, and talking astronomy were featured.

Last year, 31 telescope mirrors were ground by Toronto Centre members of the Royal Astronomical Society of Canada, including 25 mirrors six inches in diameter. Public star parties were another major group effort, about 40 being held.

G. B. C.

TRANSATLANTIC DEBATE

The origin of the moon's surface features is the subject of a debate now under way between members of the Toronto Centre of the Royal Astronomical Society of Canada and members of the Irish Astronomical Society's Belfast Centre. Each group holds a meeting at which six or seven amateurs argue the merits of various theories, and a tape recording of the discussion is then sent to the other group.

A pair of meetings has already been held, in Toronto and Belfast, and three others are tentatively programmed. R. Larsen Milling of the IAS is co-ordinator of the project, and requests that persons familiar with lunar problems send him comments, publications, and information to be used by the debaters, this data to be distributed by him to both the Irish and Canadian teams. Mr. Milling's address is Downshire House, Larne Rd., Carrickfergus, Co. Antrim, N. Ireland.

LATIN-AMERICAN LEAGUE FORMALLY ORGANIZED

The second Latin-American astronomical convention was held in Lima, Peru, from the 8th to the 15th of January. Attendance exceeded our expectations, nearly 50 delegates coming from six countries — Argentina, Brazil, Chile, Colombia, Nicaragua, and Peru. They represented 17 of the 23 organizations affiliated with the Latin-American Astronomical League.

Papers were given on various observations and researches, but our most important step forward was the formal adoption of bylaws for the league. We also laid plans for compiling and publishing the studies of our members, and made provision for the establishment of junior sections in the affiliated societies.

The new headquarters of the league are in Buenos Aires at the Asociacion Argentina Amigos de la Astronomia. Dr. Carlos L. Segers was elected new president of the league, Victorio Capolongo general secretary, and Gregorio Lipkin secretary of publications.

Our next general convention will be held in Buenos Aires in January, 1964.

VICTOR A. ESTREMADOYRO R.
Asociacion Peruana de Astronomia
Enrique Palacios 359
Chorrillos (Lima), Peru

TWO NEW GROUPS

Introductory classes in sky observing are a featured activity of the newly formed 12-member Valley Astronomy Club in Van Nuys, California. Seven refractors and an 8-inch reflector are owned by group members. Residents of the San Fernando Valley, especially beginners in astronomy, who wish to join the club should contact J. D. Truxton, 14855 Archwood St., Van Nuys, Calif.

In Rutland, Massachusetts, four amateurs have established the Pommagussett Astronomical Society. The secretary is M. S. Lubin, 45 Granite St., Worcester 4, Mass.

THIS MONTH'S PROGRAMS

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. March 10, Dr. Bengt Strömgren, Institute for Advanced Studies, Princeton, New Jersey, "The Age and Place of Formation of Stars."

El Paso, Tex.: Orion Society of El Paso, 8 p.m., Texas Western Museum. March 7, Dr. John M. Sharp, Texas Western College, "The Surface Features of the Moon."

New Orleans, La.: Pontchartrain Astronomy Society, 8 p.m., Tulane University Observatory. March 3, Dr. J. Frazer Thomson, Tulane University, "The Hazards of Space Flight."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. March 1, Dr. George B. Field, Princeton University Observatory, "Supernovae as Radio Sources."

New York, N. Y.: Junior Astronomy Club, 8 p.m., Waverly Building, New York University. March 17, Dr. George B. Field, Princeton University Observatory, "New Ideas About Jupiter."

Philadelphia, Pa.: Rittenhouse Astronomical Society, 8 p.m., Franklin Institute. March 10, Frank Holden, Sproul Observatory, "The Interferometer in Double Star Observation."

Plainfield, N. J.: Amateur Astronomers, Inc., of Union County, 8 p.m., Stillman School. March 17, John W. Thackara, "Rockets and Astronomy."

Syracuse, N. Y.: Syracuse Astronomical Society, 8 p.m., Steele Hall, Syracuse University. March 23, Sebastian Borello, "Astronomy in Antarctica."

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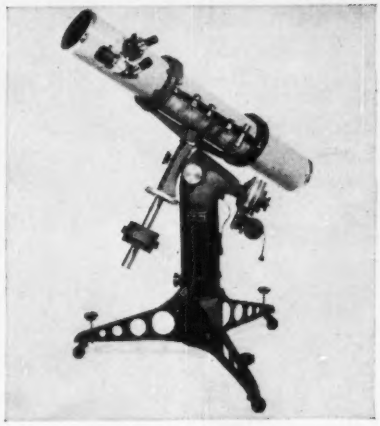

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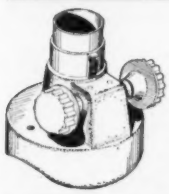

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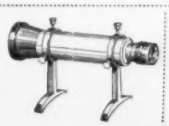

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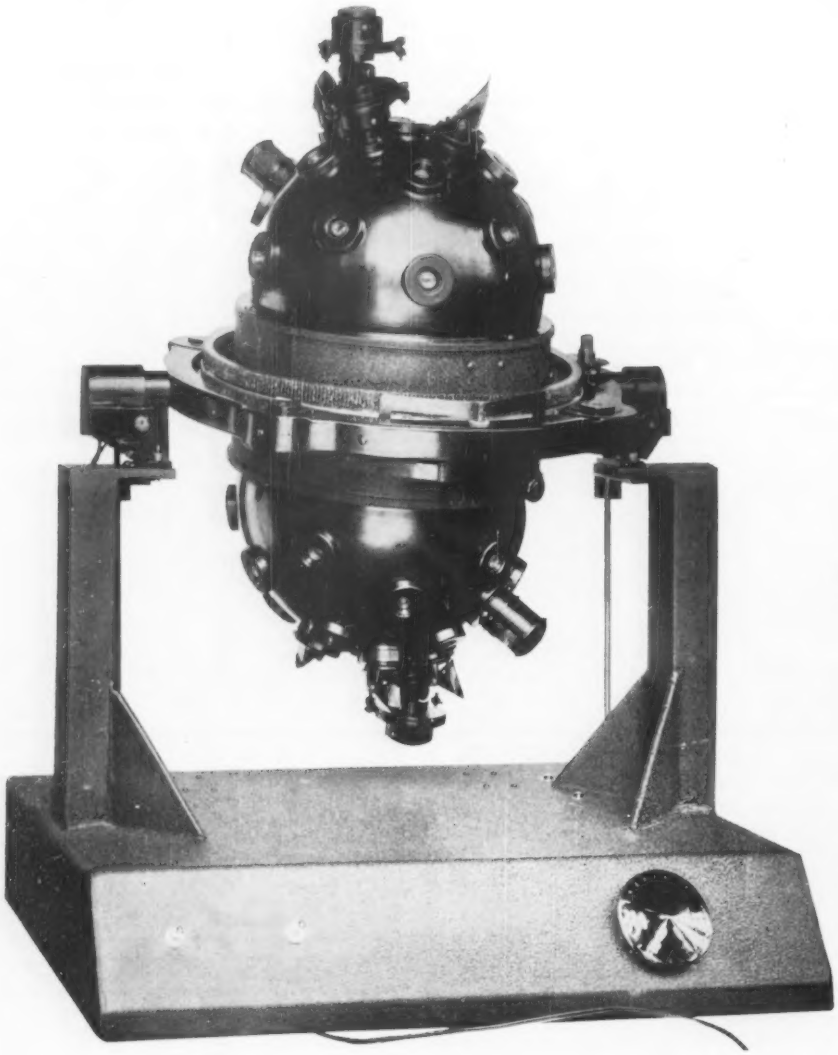

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OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

Amateur Observations of Two Recent Comets

TWO moderately bright comets have attracted the attention of observers recently — periodic Comet Encke and Comet Candy 1960n. The first was widely observed before it was lost in the solar glare preceding perihelion passage on February 5th. On the original negative of the picture below, Alan McClure measured the diameter of the coma as five minutes of arc, and the length of the faint tail as 130 minutes. About 78 minutes from the nucleus, the tail had developed a kink or bend.

During March, Comet Encke is unfavorably placed for Northern Hemisphere amateurs, being south of the sun in the morning twilight. According to the ephemeris in *Circular* 1737 of the International Astronomical Union, the predicted magnitude is 5.7 on February 15th, 10.5 on March 7th, and 13.2 on March 27th. The rapid fading occurs as the comet recedes from both sun and earth.

As reported on page 85 last month, Comet 1960n was accidentally discovered by M. P. Candy as an 8th-magnitude diffuse object in Cepheus. At the time Mr. Candy was testing an eyepiece on a 5-inch comet seeker. He has published orbital elements and an ephemeris, computed from 27 positions for December and January, in Harvard *Announcement Card* 1523. He found that 1960n was closest to the sun on February 8th, its least distance being 99 million miles.

Mr. McClure's photograph of Comet Candy, reproduced here, was taken on the same night as the picture of Encke's. At that time, 1960n was a 9th-magnitude object in Pegasus. On his plate Mr. McClure measured the coma as six minutes of arc across, the tail as 20.7 long.

A 15-minute exposure of Comet Candy, by Mr. McClure, on January 17, 1961, guided to follow the comet.

In March and early April, Comet Candy will be too near the sun to be seen, and thereafter it becomes a faint object in the southern sky.

Comet Encke, photographed by Alan McClure of Los Angeles on the evening of January 17, 1961. He used a 7-inch f/7 Fecker triplet lens for the 16-minute exposure from Mt. Pinos.

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Conjunction of Venus and the Moon

ON JANUARY 19-20, 1961, the moon occulted Venus for observers in the South Pacific and Australia. Though the actual occultation was not visible from the United States, viewers could see the 3½-day-old crescent approaching Venus as the two set in the southwestern sky.

At Wilmette, Illinois, H. D. Isenberg photographed the spectacle at 23:55 Universal time on January 19th, about five hours before geocentric conjunction. Burton G. Ford, Ft. Worth, Texas, exposed one negative at half-hour intervals beginning at 2:05 UT on the 20th. The last of his three exposures, which show clearly the lessening distance between moon and planet, was taken two hours before conjunction. Mike Hudson, La Mesa, California, took a similar series of five exposures.

Clouds bothered C. M. Brainard's attempt to witness the approach from Hollywood, California, but he managed to secure the accompanying picture at 2:24 UT.

The occultation was visible as a daytime event in Australia, where 13 members of the North Shore Astronomical Society timed the phenomenon with seven instruments: one 9- and two 6-inch reflectors, one 3.6- and three 2.4-inch refractors. From their location at Hornsby, New South Wales (east longitude 151° 05′ 40″, latitude −33° 41′ 26″, elevation 600 feet), the average of two timings for the disappearance of the second cusp was 4:59:32.2 UT.

Venus came from behind the moon's limb near Mare Crisium. The first cusp reappeared at 6:26:58.2 UT, the second 28.3 seconds later. The reference clock was set by Sydney Observatory time signals. Seeing was 7 to 8 on a scale where 10 represents perfect skies.

A 4-inch f/6 lens and Polaroid film were used by C. M. Brainard to photograph Venus and the moon on the evening of January 19th.

In Texas, Burton G. Ford employed a 10-inch Ektar lens at f/8 to record the moon and Venus on January 19-20. Exposures on Royal Pan film were (top to bottom) 1/10, 1/5, and ½ second.

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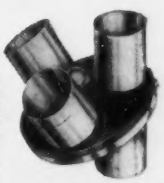

The Criterion Revolving Turret holds three eyepieces so that, as desired, the power of the telescope can be changed by merely turning the turret to a different ocular. Click stop insures positive and accurate positioning of each eyepiece. Turret holds eyepieces of standard 1¼" outside diameter. Fits into the holder of any refractor or reflector telescope that uses 1¼" eyepieces. Requires no alteration or adjustment and can be attached as easily as putting eyepiece into scope. Made of brass and aluminum with polished chrome-plated barrels.

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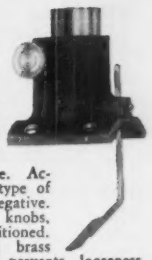

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S-55	2.00"	11" to 11½"	**14.95**
S-56	2.50"	Specify tube I.D.	**19.95**

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The southern Milky Way from the star clouds of Sagittarius (lower left) to Carina (upper right), photographed by Marcos A. Severin in Argentina with a 35-mm. camera. The exposure was 100 minutes on Agfa Isopan F film, the lens used being an f/4.5 Zeiss wide-angle Biogon of 21 millimeters focus. At left is the Scorpion's tail, while at upper right is the Coal Sack; next to it and above is the Southern Cross.

Milky Way Photography Without a Clock Drive

MY ATTEMPTS at photography of the Milky Way with short-focus lenses have achieved success, due in part to the drive arrangement for my 35-mm. Contax camera shown opposite. The light equatorial mounting is hand-driven in right ascension, yet is quite satisfactory for exposures as long as 100 minutes. The mechanism is similar to one described by J. Texereau and G. de Vaucouleurs in the book *L'Astrophotographie d'Amateur*.

The motion of a nut along the horizontal screw is transmitted to the radius arm by a simple linkage. The arm, clamped to the polar axis during operation, may be easily loosened in order to reset the screw. This arrangement would not work if the screw were motor-driven, because it must be turned at different speeds when the nut is near the ends

This 60-minute exposure of the Large Magellanic Cloud was made by the author with an f/2 Sonnar lens of 85 millimeters focus on Agfa Isopan F film. North is at the top in this reproduction, east to the left. The bright star an inch from the left and near the top is Delta Doradus; another an inch from the right and ¾ inch from the bottom is 5th-magnitude Beta Mensae.

Mr. Severin's camera (upon the guide telescope) and mounting. The instruments are driven in right ascension by an arm that is moved by the large screw that the boy is holding.

than when it is in the center. Varying the rate is not troublesome, however, when the screw is turned by hand.

At first I employed a 3¾-inch f/10 reflector as a guide telescope, but it proved to be too large and heavy for my little mounting. I therefore adopted a 3¼-inch surplus doublet. This f/5.5 rich-field telescope is light and compact, and with medium-focus corrected eyepieces (Kellner or Plössl) gives sharp star images over a wide field of view.

The star photographs with this article, as well as those in SKY AND TELESCOPE for October, 1959 (pages 670, 671, and 693), were taken on fast film with my hand-driven instrument.

MARCOS A. SEVERIN
Sgto. Cabral 238
Rafaela, Santa Fe, Argentina

SUNSPOT NUMBERS

The following American sunspot numbers for December, 1960, have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

December 1, 71; **2,** 85; **3,** 74; **4,** 85; **5,** 87; **6,** 73; **7,** 67; **8,** 71; **9,** 80; **10,** 84; **11,** 85; **12,** 74; **13,** 75; **14,** 97; **15,** 100; **16,** 97; **17,** 80; **18,** 71; **19,** 65; **20,** 56; **21,** 60; **22,** 48; **23,** 39; **24,** 43; **25,** 40; **26,** 55; **27,** 65; **28,** 73; **29,** 108; **30,** 106; **31,** 107. Mean for December, 74.8.

Below are provisional mean relative sunspot numbers for January by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations in Locarno and Arosa.

January 1, 128; **2,** 123; **3,** 109; **4,** 84; **5,** 78; **6,** 69; **7,** 60; **8,** 52; **9,** 52; **10,** 49; **11,** 39; **12,** 31; **13,** 28; **14,** 21; **15,** 20; **16,** 31; **17,** 43; **18,** 51; **19,** 50; **20,** 45; **21,** 50; **22,** 37; **23,** 27; **24,** 18; **25,** 35; **26,** 48; **27,** 43; **28,** 62; **29,** 68; **30,** 55; **31,** 52. Mean for January, 53.5.

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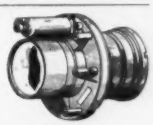

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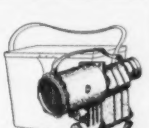

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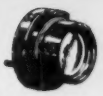

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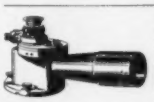

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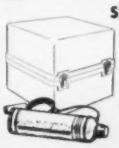

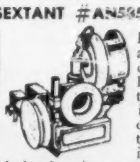

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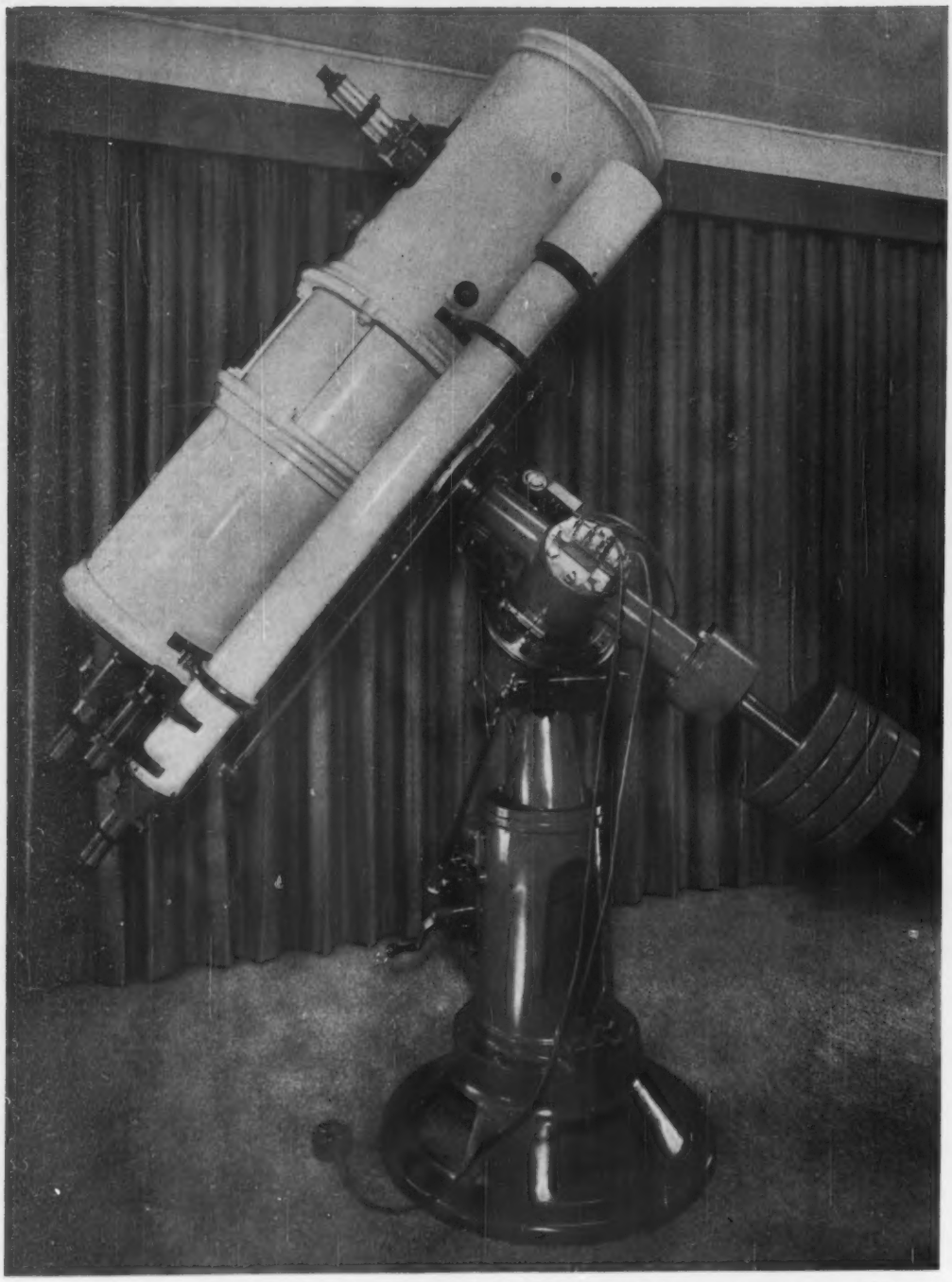

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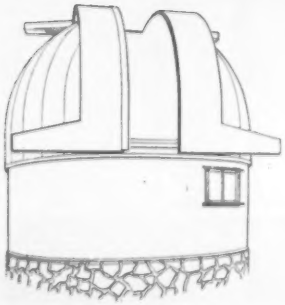

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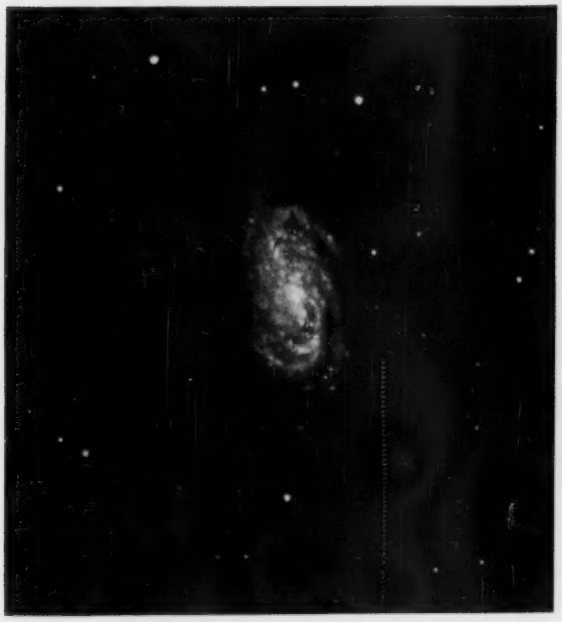
DEEP-SKY WONDERS

ALTHOUGH spring heavens seem dark, compared to the brilliant constellations of winter and summer, many fine telescopic objects are now in good position for observing. One of the more noteworthy is the open cluster M67 in Cancer, at right ascension $8^h\ 48^m.3$, declination $+12°\ 00'$ (1950 co-ordinates). Distant 2,700 light-years according to H. L. Johnson, M67 is believed to be among the oldest galactic clusters.

This 6th-magnitude object is just visible to the unaided eye. The Skalnate Pleso catalogue lists it as having 65 stars within its boundaries, 15′ across. Viewed in Kansas with a 10-inch telescope, it appeared as an irregular mass of stars, many of them 8th to 9th magnitude. On especially clear nights, the pin points of light seemed to number over a hundred. M67 is a delightful view through large binoculars, such as 15 x 65's.

North of M67 is better-known M44, the Praesepe or Beehive, at $8^h\ 37^m.5$, $+19°\ 52'$. On a clear dark night this open cluster is an easy naked-eye object, and its invisibility indicates the presence of cirrus or haze. The Praesepe group has long been a favorite of young amateurs testing their plotting skill. Hand-guided photographs with a small camera can yield surprising results.

In this general region of the sky are two galaxies that can be readily observed with medium-size telescopes. The first is NGC 2903, at $9^h\ 29^m.3$, $+21°\ 44'$, in Leo. This 9th-magnitude 11′-by-5′ spiral presents a rather strange appearance in small instruments, seeming to be a double object, and William Herschel actually described it as two nebulae, numbered by him I56 and I57. Curiously, Admiral Smyth and Herschel disagree as to which end is brighter. The *New General Catalogue* cites 2903 (I56) as bright, 2905 (I57) as very faint. In a 6-inch rich-field telescope, there does not seem to be much difference between the ends. Other amateurs may wish to see if they can note any striking anomaly, and could report their results to me on a post card.



The spiral galaxy NGC 2903, photographed at the turn of the century with the 36-inch Crossley reflector of Lick Observatory. In the November, 1960, "Astrophysical Journal," a study of this galaxy's rotation is reported by E. Margaret and G. R. Burbidge, and K. H. Prendergast, of Yerkes and McDonald Observatories. They find that from the center to about 80 seconds of arc outward, the velocity of rotation increases to 200 kilometers per second, thereafter leveling off or decreasing. This indicates a mass of 40 billion suns, if NGC 2903's distance from us is 20 million light-years. Photo from Lick "Publications," 1908.

NGC 2775 is another easy galaxy, though quite a bit smaller than 2903, being 2′ by 1′, and only 11th magnitude. A fine object in a 4-inch, it is easy to find if its position ($9^h\ 07^m.7$, $+7°\ 15'$ for 1950) is first plotted in a star atlas such as Webb's or the Beyer-Graff, allowing for precession. Older books put this spiral in Hydra, but the constellation boundaries adopted in 1930 by the International Astronomical Union place it in Cancer.

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CORRECTION

In the table on page 18 of the January issue, the latitude of Caracas, Venezuela, should read $+10°\ 29'$ rather than $-10°\ 29'$. However, the correct value was used in the computations. The error was pointed out by F. Rodriguez-Gil of Caracas.

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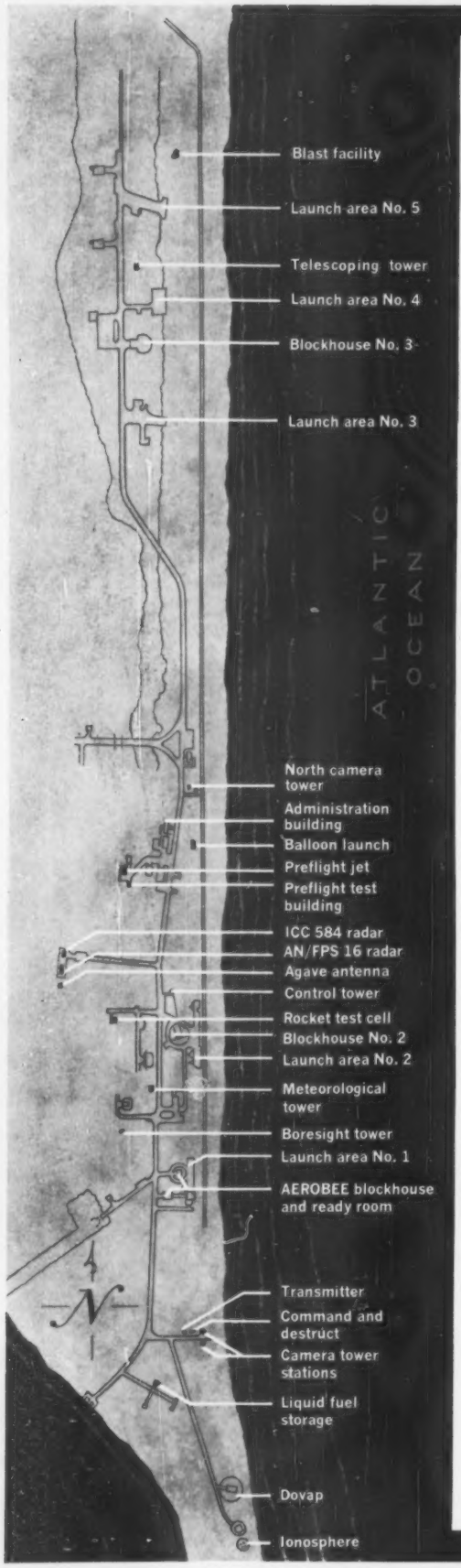

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BOOKS AND THE SKY

SOURCE BOOK IN ASTRONOMY 1900-1950

Harlow Shapley, editor. Harvard University Press, Cambridge, Mass., 1960. 423 pages. $10.00.

THIS new contribution to the Source Books in the History of Sciences series may well stimulate the following recreation in astronomical circles: Select the 10 (or 20) most outstanding astronomical papers from the first half of our century. The most obvious approach would be to tabulate the significant general developments of astronomy during those five decades.

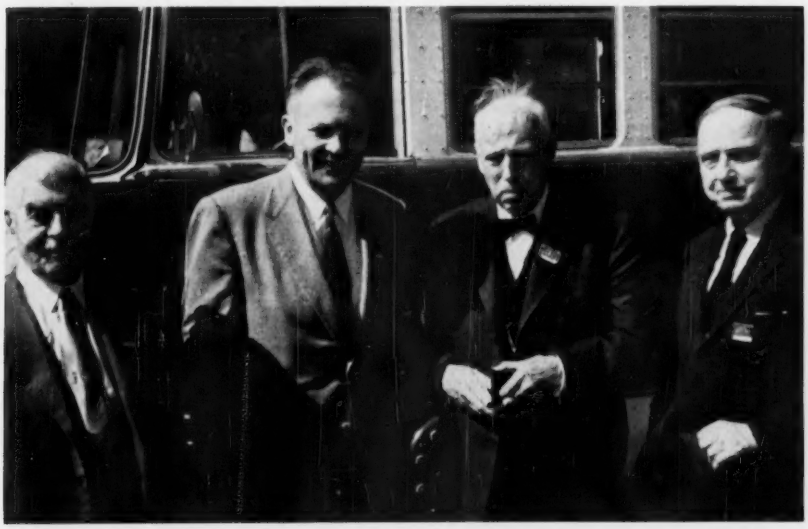
The size of our galaxy and its rotation, the distances and velocities of other galaxies, interstellar matter, nuclear energy and the internal structure of stars, the relation of stellar luminosities to their spectra, the interpretation of stellar spectra themselves as a result of new understanding of atomic structure, ionization, and excitation — these would rank high in any such list of achievements between 1900 and 1950.

But to enumerate these important successes is a simple task compared to selecting the key papers in which each new idea is set forth. Occasionally, a significant concept is well developed when it first appears in astronomical literature, for example, Walter Baade's classic paper on stellar populations in Vol. 100 of the *Astrophysical Journal.* Other ideas come forth piecemeal, such as Harlow Shapley's brilliant work on the place and distance of the center of the Milky Way galaxy, for which the evidence was given in a long series of articles.

If to this difficulty is added the requirement that the papers in question be understandable and interesting to an intelligent general reader, then it will no longer be possible to represent all the leading astronomical developments in a selection of papers in which some discovery is first described. This, in fact, was the dilemma faced by the editor of *Source Book in Astronomy 1900-1950.* Thus, the important original mathematical contributions of Saha, Eddington, Milne, Karl Schwarzschild, and many others, will not be found in this collection of 69 articles.

Dr. Shapley has resolved this problem in a twofold manner. First, a number of original contributions *are* included: the previously mentioned paper by Baade, Albert Einstein's $E = mc^2$ paper translated from *Annalen der Physik,* the two early articles by Ejnar Hertzsprung and by Henry Norris Russell that founded the idea of the H-R diagram, Jan Oort's contribution on galactic rotation (although the mathematical development has been omitted), V. A. Ambarzumian's discussion of stellar associations, Grote Reber's "Cosmic Static," H. van de Hulst's prediction of the 21-cm. hydrogen line, and so on. The editor has also located Sir James Jeans' original suggestion that the transformation of matter into energy could keep the stars shining.

Second, some important discoveries are described in later review articles by their original authors. Among these is the longest and one of the most readable selections in the book, from Sir Arthur Eddington's *Stars and Atoms.* Shapley's own discussion, "From Heliocentric to



While at the Moscow meeting of the International Astronomical Union in 1958, Owen Gingerich, author of this book review, photographed a group of internationally famous astronomers. Left to right. they are the late F. J. M. Stratton of Cambridge, England (see page 144); G. P. Kuiper, then of Yerkes Observatory; E. Hertzsprung of Denmark; and Harlow Shapley, former director of Harvard Observatory and editor of the book being reviewed.

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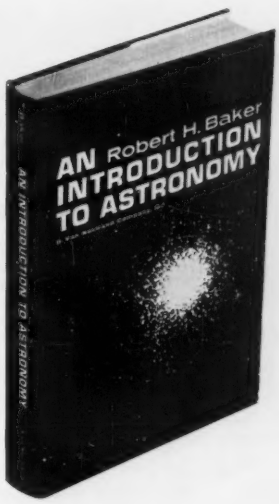

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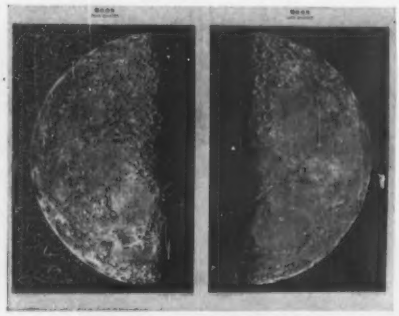

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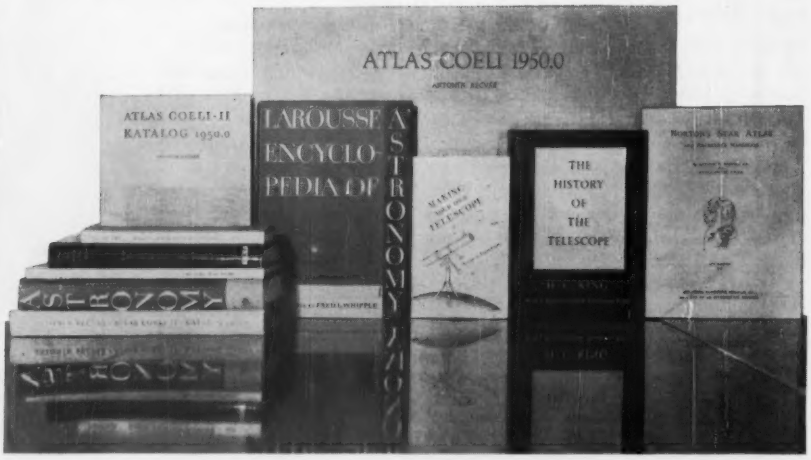

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Galactocentric," comes from *Star Clusters*, written about 15 years after his pioneering investigation. The *Leaflets* of the Astronomical Society of the Pacific are the source of half a dozen selections, such as Clyde Tombaugh's "The Discovery of Pluto." A few articles are apparently selected to include a particular author, even though the subject is not directly his principal contribution, such as Meghnad Saha's "A Stratospheric Solar Observatory."

The resulting collection might better have been titled *Readings in Astronomy*, although the other name is required by the series. Had this title been adopted, the book might reach a wider college audience, for it should be required reading for every astronomy major.

Dividing the selections into 13 subject groups, in chronological order within them, the editor has preceded each section with a short discussion of the principal developments in that field. He also calls attention to contributions too technical to be included.

Because of the two types of articles that constitute this volume, an easily understood selection is frequently followed by one of comparative difficulty. This probably doesn't matter too much, since many readers will keep the book for reference purposes and few will read it from beginning to end. Nevertheless, it would have helped to have the source identified on the same page as the beginning of each article (instead of being placed in the long list at the end of the volume). And a few statements should have been made concerning the nature of the selection and its relation to the original discovery.

The 1950 terminal date dramatically points up the advances in astronomy in the 10 years since then. The spiral arms of the Milky Way, optical identification of radio sources, synthesis of elements in stars, and stellar evolution are but a few of the important topics not included in this volume.

Many astronomers will notice the absence of papers they would have chosen within the 1900-1950 period, but considering the scope of the source book and its inherent restrictions, we must thank Dr. Shapley for so boldly attacking this not uncontroversial task.

OWEN GINGERICH
Smithsonian Astrophysical Observatory

BEYOND THE PLANET EARTH

Konstantin Tsiolkovsky. Pergamon Press, Inc., New York, 1960. 190 pages. $3.75.

ONLY RARELY is a work of science fiction reviewed in this department, but because of its scientific content and historical significance, *Beyond the Planet Earth* can be recommended to both occasional and serious readers of astronomical literature. Completed just after World War I, and incorporating ideas developed over 40 years, this book portrays graphically the possible situations and problems to be met by pioneer human visitors to outer space. This first English translation is by Kenneth Syers.

Konstantin Eduardovich Tsiolkovsky (1857-1935) was an unusual amalgamation of scientist and romantic, mathematician and dreamer, who anticipated much of Robert Goddard's and Hermann Oberth's rocket work. In addition, he devised plots and schemes for extraterrestrial adventures in the spirit of Jules Verne. Son of an underpaid forester and inventor, he was left almost totally deaf by an attack of scarlet fever at the age of nine. Thus forced to withdraw from his school and friends, young Tsiolkovsky found refuge in his father's library, reading voraciously in mathematics and physics. Wings fascinated him, and every opportunity to create and experiment with wood and tissue models of aircraft was enthusiastically seized.

At great family sacrifice, the boy was enabled to go to Moscow. Existing on a most meager allowance, Tsiolkovsky stayed there three years, haunting the libraries. His dank room was a maze of experimental apparatus; he starved himself to pay for books and chemicals.

Despite his lack of a high school diploma, Tsiolkovsky passed the teaching examinations and settled down in Kaluga province, to become a mathematics and physics teacher held half in awe, half in derision by his neighbors. Although several of his inventions caused local stir, for instance a vulture of 28-inch wingspread that soared superbly, he was neglected by the outside world. His proposal for a long-range rocket reached the Russian Chief Artillery Office just after the outbreak of World War I, but was largely ignored.

Many of his papers, both published and unpublished, presented ideas that are current today. In 1883 he declared that "reactive movement" should be considered a force in flying, and in 1886 he worked out a structure for a metal-

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Dr. Paul
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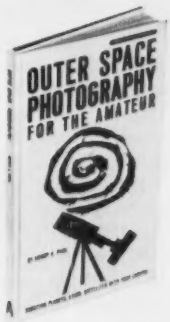

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surfaced dirigible. He planned to use artificial satellites as bases for space probes; to create artificial weight in a satellite by rotating it about its own axis; to use seaweed as a space traveler's food; and to float living creatures in baths of liquid in order to protect them from tremendous accelerations and decelerations.

Recognition came only gradually. In 1918, after the revolution, Tsiolkovsky was elected a member of the Socialist Academy (which later became part of the U. S. S. R. Academy of Sciences); a modest subsidy was assigned him. His articles began to appear at public expense, and he was freed to carry on the experiments he had long desired.

Tsiolkovsky's wide interests are illustrated by *Beyond the Planet Earth*, for it is more than a listing of the author's ideas for the first spaceflight. It is a sounding board upon which he expresses his feelings toward nature, man, and society.

The story is set in the year 2017. High in the Himalayas stands the castle of six immensely wealthy researchers who, disillusioned by the pleasures and people of the world, have sought a refuge where they may devote themselves to the abstract and lofty ideals of science. Franklin, Galileo, Helmholtz, Ivanov, Laplace, Newton — each man possesses a distinguishing characteristic, be it precision, imagination, profundity, or practicality. The Russian, Ivanov, is the character most like Tsiolkovsky himself, a dreamer who has the erudition and ability to implement his ideas. He is the one who bursts forth with plans for a spaceship; it is he who first ventures to land upon the moon.

This fictional first space trip is an unqualified success; indeed, by the time the first travelers return to earth, many orbiting colonies spawned by their pioneering efforts are already functioning. As a scientist, Tsiolkovsky computes and analyzes all possible situations that might arise, so the unexpected simply cannot happen. Even the problem of bathing in gravityless space is taken in hand: A hollow, slowly rotating cylinder is half filled with water that collects at its circumference; the bathers, swimming and splashing quite normally, sit with their heads toward the center.

Several incidents and objects mentioned in the book seem incongruous today. For example, radio communication did not exist when Tsiolkovsky started to write, so the spaceship signals by means of mirrors or flashing lights, and men in spacesuits talk to each other by touching helmets or by vibrating wires stretched between them. Nevertheless, one must admire the fertile imagination of the author, out of touch as he was with the main stream of western scientific thought at the turn of the century.

Considered for the number of thought-provoking inventions and ideas it presents, and for the historical background in which it was produced, *Beyond the Planet Earth* is a most illuminating work. It is fantasy, to be sure, but written in a responsible and extremely readable manner.

G. B. C.

NEW BOOKS RECEIVED

ASTRONOMISCHER JAHRESBERICHT, Vol. 58, 1960, *Astronomisches Rechen-Institut*, Mönchhofstrasse 12-14, Heidelberg 17a, West Germany. 567 pages. DM 60, paper bound.

The world's astronomical literature published in 1958 is comprehensively listed in this latest annual volume of a standard reference work. Titles are arranged by subject, with short abstracts in German for the more important references. The alphabetical subject index is in English.

PRINCIPLES OF METEORITICS, *E. L. Krinov*, 1960, *Pergamon*. 535 pages. $12.00.

Originally published in Russian in 1955, this technical monograph provides a thorough survey of modern research on meteorites, with emphasis on Soviet work. This translation is by Irene Vidziunas and was edited by Harrison Brown; some more recent material has been added by the author. The well-illustrated text is supported by a 270-entry bibliography.

FUNDAMENTAL PHYSICS, *Jay Orear*, 1961, *Wiley*. 381 pages. $6.75.

Equations, diagrams, and illustrative problems are used by a Cornell University scientist to explain systematically the basic principles in various branches of modern physics. This book is intended for college students not specializing in physics but having some background in mathematics.

GALILEO IN CHINA, *Pasquale M. D'Elia, S. J.*, 1960, *Harvard University Press*. 115 pages. $4.00.

A little-known chapter in the history of astronomy is the spreading of Galileo's discoveries by Jesuit missionaries to China. This scholarly account, based on Italian and Chinese documents, traces Galileo's influence in the Far East up to the point of his death in the 1642. The book is a translation by Rufus Suter and Matthew Sciascia of two lectures given at Rome in 1942, with added notes.

ORDERS FOR BACK ISSUES

The stock of back numbers of this magazine for the first 16 volumes (November, 1941, to October, 1957) has been transferred to Walter J. Johnson, Inc., 111 Fifth Ave., New York 3, N. Y., from whom issues still in print may be ordered. That company is at present reprinting the first four volumes in photo-offset form, to be available later this year. Eventually, as demand warrants, other out-of-print numbers will be reissued.

Recent back numbers, Vols. XVII to the present (beginning November, 1957), should be ordered from the circulation office of SKY AND TELESCOPE, 49 Bay State Rd., Cambridge 38, Mass. All issues except April and November, 1958, and September, 1959, are in good supply. The price is 75 cents per copy, including mailing, $6.00 for 12 issues ordered at one time.

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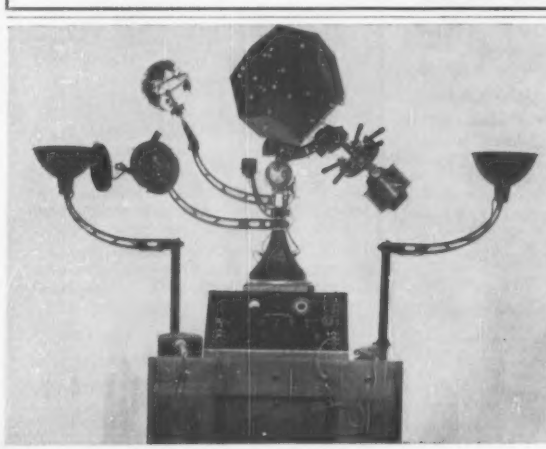

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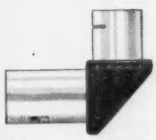

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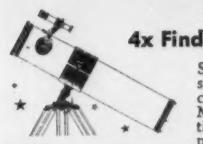

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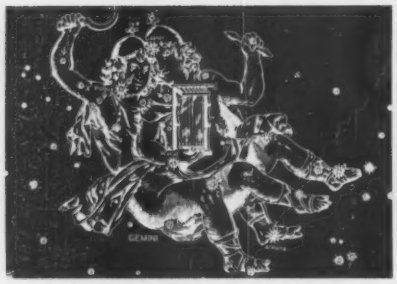


constellation of the month

GEMINI

A favorite star group among watchers of March skies is Gemini, the Heavenly Twins. Naked-eye observers know it as one of the few constellations whose form really fits its name. From its brightest stars, Castor and Pollux, run two nearly parallel lines picked out in stellar pin points, marking the mythical brothers. This month, however, all are outshone by a visitor within the constellation — the brilliant red planet Mars.

Gemini is a fine region for sweeping with binoculars, or even better, a UNITRON finder used as a hand-held instrument. Look near the 3rd-magnitude stars Eta and Mu Geminorum for the famous cluster Messier 35, a misty knot of faintly glittering points of light.

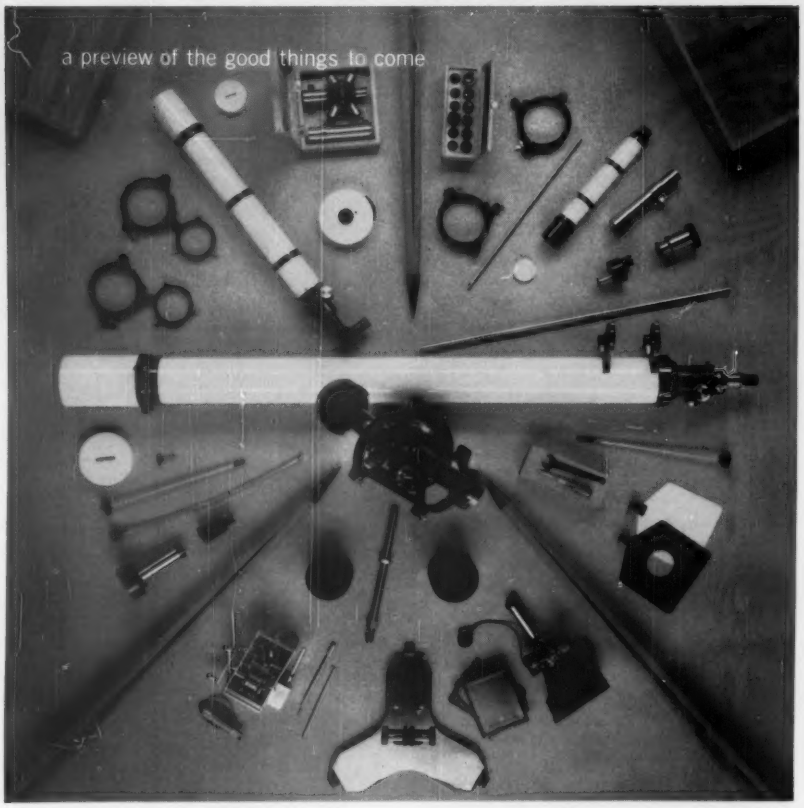
For a closer view of it, choose a low magnification on a UNITRON 2.4-inch or 3-inch, and see this cluster as a bright swarm of distant suns. Open star clusters such as this are good subjects for astrophotography; the owner of a UNITRON Photo-equatorial who takes a carefully guided half-hour exposure will be rewarded by a faithfully accurate, permanent record of this remote stellar system.

The double stars of Gemini offer much to users of popular-size refractors, especially on nights of good seeing, when there is little or no twinkling. Nu Geminorum, magnitudes 3 and 4, is a very wide, easy pair in a 1.6-inch UNITRON; look two degrees south of it for the 20-second pair 20 Geminorum, magnitudes 6 and 7.

With a 3-inch aperture, try for the 8th-magnitude companion to Delta Geminorum, seven seconds distant. Rather more difficult is Lambda, accompanied by a faint 10th-magnitude secondary, 10 seconds away.

The owner of a 4-inch UNITRON will find the brilliant binary pair Castor a fine object. It consists of a 2nd- and a 3rd-magnitude star, only two seconds of arc apart in the present stage of their four-century orbital motion. For best results on this rather close pair, use high power on a night with steady seeing. Note also the 9th-magnitude companion about a minute of arc distant, making Castor a visual triple star. The view in a 6-inch UNITRON is even more striking.

UNITRON of the Month . . . . . Model 160



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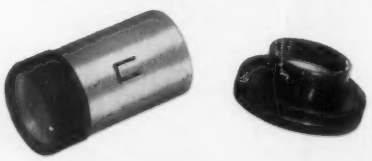
This useful and valuable accessory **is now included as standard equipment** with all UNITRON Refractors at **no additional cost** . . . another of the many reasons why the telescope you choose should be a UNITRON.



CALLING ALL UNITRON OWNERS!

If you purchased a UNITRON before the Achromatic Amplifier was available, we want you to have the chance to get one, and offer it at the special price of $6.00 — less than one-third the price you'd pay elsewhere for an accessory of this quality. This offer is for UNITRON owners only. (When ordering, please state whether for UNIHEX or star diagonal.)

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2.4" EQUATORIAL ($22.50 Down) with eyepieces for 129x, 100x, 72x, 50x, 35x — **$225**

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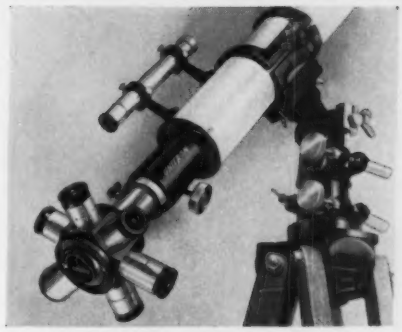
Do you lie awake nights fretting over the fact that you are not a UNITRON owner? Do you have to lull yourself to sleep by counting UNITRONS? Worse still, do you see yourself in nightmares, tunneling under the foundations of the UNITRON plant to make off with one of America's most popular refractors? If this is your problem, neither medical attention nor a soporific is needed to cure you. In the language of the layman, you need a UNITRON!

Fortunately, it's so easy to own a UNITRON, even if you find it inconvenient to pay for it all at once. Using UNITRON's Painless Payment Plan, a mere 10% down will focus the universe on your retina. The monthly payments, which extend over a year or more, are small indeed compared to the cost of an equivalent period of psychoanalysis. At the end of this time you will have something permanent to show for your money — a UNITRON, to give you a lifetime of observing pleasure.

So, instead of a page from a physician's prescription pad, take the Easy Payment Order Form found in the UNITRON catalog, fill it in, and mail it together with your down payment. Unlike other time-payment forms, ours is neither a comprehensive financial quiz nor an attempt to probe your subconscious. All you need tell us is your name and address (so we'll know where to ship your telescope) plus a few other bits of readily available data. In little more time than it takes to reach for a sleeping pill, your UNITRON will arrive. Then you will really stay awake nights! But now it will be by choice — at the controls of your UNITRON.

UNITRON of last month



2.4" ALTAZIMUTH REFRACTOR

For those of you who missed last month's featured UNITRON, we're bringing it back for this month so you can see what you missed last month. If you plan on missing next month's, look on the facing page for **this** month's featured UNITRON. Take a good look at it, because we can't guarantee we'll bring it back **next** month as last month's. There's a limit to how long you can keep up this sort of thing. Anyway, last month's UNITRON is one wonderful deal for just $125.

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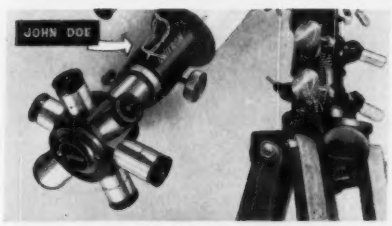
Send check or money order in full or use our Easy Payment Plan. Shipments made express collect. Send 20% deposit for C.O.D. shipment. UNITRON instruments are fully guaranteed for quality, workmanship, and performance, and must meet with your approval or your money back.

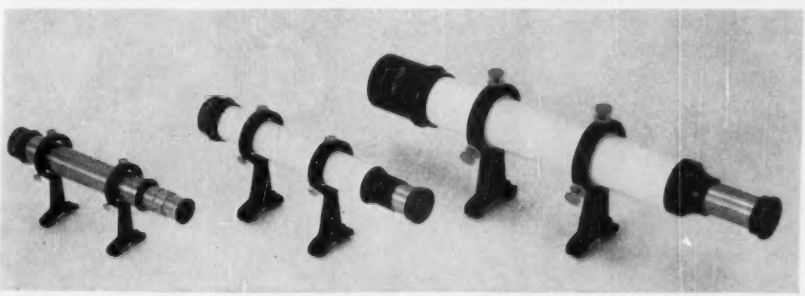
IT HAD TO HAPPEN: A UNITRON WITH YOUR NAME ON IT!



We've gone and done it. We've personalized the telescope business. For a limited time, when you buy a UNITRON, you can have your name embossed in a plastic name plate attached to the gleaming black barrel at no charge.

People tell us they like it. It's in quiet good taste, yet it seems to give that extra fillip to the pride of ownership people feel for their UNITRONS. To get your name plate simply add this statement to your order: Please attach a name plate to my telescope. This is the name: (print name clearly).

New UNITRON View Finders



UNITRON's popular view finders with newly designed optics and mechanical features are better than ever. From left to right: 23.5 mm., 30 mm., 42 mm.

1. VIEW FINDER (Used on UNITRON 2.4" Equatorials): 23.5-mm. (.93") achromatic objective, 6x eyepiece with crosshairs. Chromed brass tube. Mounting brackets with centering screws.
Only $8.50 postpaid

2. VIEW FINDER (As used on UNITRON 3" Refractors): 30-mm. (1.2") coated achromatic objective and 8x eyepiece with crosshairs. Other details as in View Finder 3.
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3. VIEW FINDER (As used on UNITRON 4" Refractors): 42-mm. (1.6") coated achromatic air-spaced objective. 10x eyepiece with crosshairs. Duralumin tube finished in white enamel. Dewcap. Furnished with mounting brackets, centering screws for collimation, and mounting screws. This finder measures approximately 16" overall. It is light in weight, compact and small enough for use as a hand telescope furnishing spectacular wide-field views of the sky.
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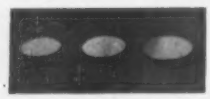

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A Precision Device To Measure Knife-Edge Settings

ACCURATE MEASUREMENTS of the zones on my telescope mirrors in Foucault testing were always difficult until I adopted the mechanical stage of a microscope as the knife-edge support. Now I am able to control the knife-edge's position very precisely and read the shadows on the mirror much more closely.

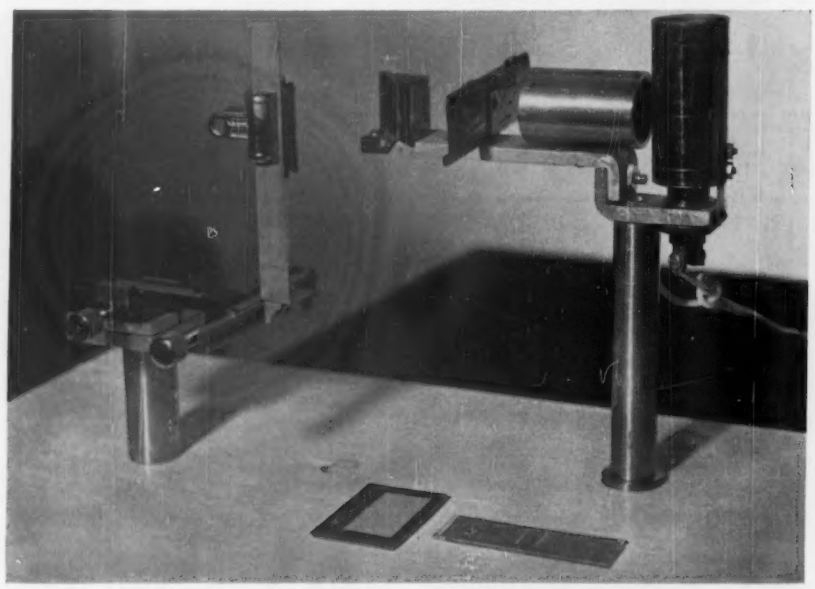
A microscope's mechanical stage can be likened to a two-co-ordinate measuring machine used by astronomers to find the positions of stars on a photographic plate of the sky. The stage carries the microscope slide and shifts it a known distance longitudinally and laterally, permitting the measurement of a position anywhere on the slide and accurate relocating of any part of an object being examined. For this purpose, the stage must have carefully machined ways and a rack-and-pinion or screw control in each direction. Further, the scales must be very accurately graduated in millimeters, and they are often equipped with verniers to permit reading to 1/10 millimeter.

According to many professional optical workers, amateurs cannot expect to make consistent readings of mirror zones to closer than 0.010" in knife-edge position, certainly no better than 0.005". As 1/10 millimeter is 0.004", a vernier-equipped microscope stage provides all the accuracy the average amateur needs for general work. Only such tests as the Gaviola or caustic (*Amateur Telescope Making—Book Three,* page 429) require a more accurate reading device.

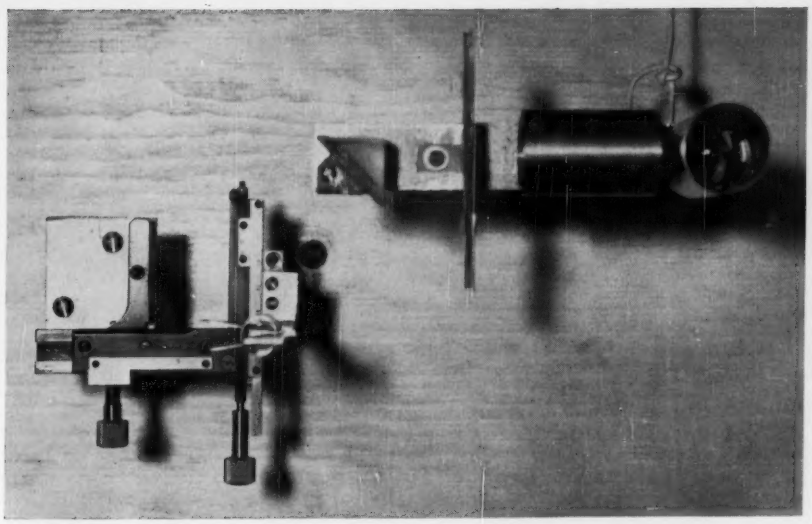
The pictures show the adaptation of my mechanical stage for the Foucault test, although it can be readily applied to the Ronchi and Dall null tests as well. Below is a general view of the setup I use, the light source and prism unit seen at the right, the knife-edge and microscope stage at the left. For testing, the direction to the mirror is toward the back in this picture, but it is beyond the top of the second photograph, which was taken with the camera pointing vertically downward.

A short brass post supports the microscope stage, and a taller post the light-source assembly. Two screws hold a square aluminum block to the short post, and one screw in the stage's left arm fixes it to the block. The other arm of the stage carries a movable slide in which I drilled and tapped two screw holes to fasten the short section of a bent piece of flat aluminum. The long upright part of this aluminum carries the knife-edge (razor blade) held in place with a spring-type paper clamp. The height of the knife-edge can be adjusted at will, while its position in the horizontal plane is controlled by the two knobs of the microscope stage.

The light itself is housed in the vertical cylinder; the horizontal tube contains condensing lenses. Next there is a pinhole slide, and then a right-angle prism to allow working close to the optical axis to minimize astigmatism. I use small, low-voltage bulbs to reduce the amount of heat, but operate them a little above



This Foucault testing device, with a mechanical microscope stage (left) used as a support for the knife-edge, was built by J. Dexter Eoff. The light source, condensing lenses, pinhole screen, and right-angle prism are carried on the tall post at the right. In the foreground are a Ronchi screen and a slide with slits of different widths. Photographs by the author.



Looking down on the testing assembly, so the vertical knife-edge is barely discernible but the parts of the microscope stage are well shown at the left. The large screw heads hold the aluminum block to the short post, and a small screw fastens the left arm of the stage to the block. At the side of the microscope scale that extends upward in this picture is the short flange of the vertical strip, with two small screws holding it to the slide on this arm of the stage. The dark round hole above this flange is in the base table, and is used to support an upright for a Dall null tester. The light source is at the right, and the tube contains the condensing lenses.

their rated voltage to increase light output. Although the bulbs burn out rather quickly, the advantages outweigh the cost.

The pinhole slide consists of a piece of glass to which is cemented a thin brass plate. In this is punched a series of holes, varying in size from a little less than 0.002″ to about 0.008″, allowing me to

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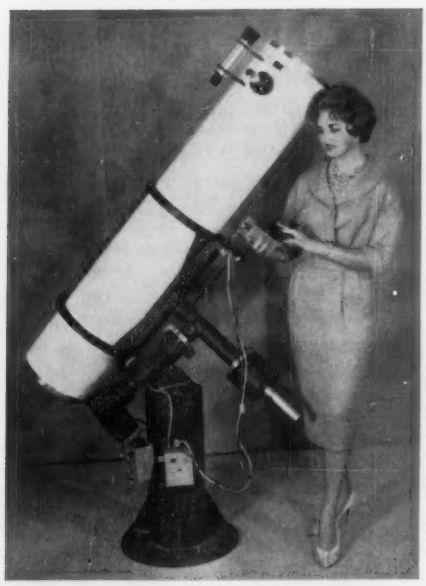

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select the size best suited for the stage of the work. Making the pinholes was simplified by a guide to help keep the punch normal to the brass surface at all times. The guide was a piece of brass rod, drilled longitudinally for a close fit with the punch.

Much time was spent making the punch from a piece of tungsten steel, which was sharpened by turning it at high speed against carborundum. Final polishing was on a hard Arkansas stone.

In making the pinholes, the punch was placed against a fine line scribed on the brass sheet, and, while the guide was held firmly against the sheet, pressure and rotation were applied to the punch. Some practice was necessary before proper hole sizes could be obtained with any degree of certainty. The guide prevented the punch from slipping during drilling or removal from the material, thus helping to obtain a round, smooth hole in the thin brass.

For the qualitative Ronchi test, the slide with the pinholes is replaced with one containing slits in a variety of widths. The slits were cut in a piece of tin foil cemented to a glass microscope slide. In the picture on page 172, this slide lies to the right of the Ronchi screen, a bit of miller's silk cemented to a frame cut from a piece of thin sheet copper. The screen is fastened to the mechanical stage upright in place of the knife-edge.

For the Dall null test, the light source is either removed or rotated out of the way, while another upright post carrying the tester is placed in the hole seen in the base table between the stage and light-source assembly.

I have tried an American microscope stage, but Japanese assemblies seem to have better arrangements of controls. For less than seven dollars, Lafayette Radio offers a stage with vernier scales. However, the one with more conveniently arranged controls shown in the pictures with this article costs nearly three times as much, and is available from the same supplier.

Some amateurs may have microscope equipment they can temporarily adapt to Foucault testing. With vernier scales the settings are read directly, the zonal shift of the knife-edge being obtained merely by subtracting one reading from the other. If a unit has no scale at all, mount on the base a short section of a rule graduated to 1/100 of an inch, and put a pointer on the carriage.

Even the simple scheme of a piece of paper placed on the base and marked with successive positions of the carriage end will serve, when measured with a finely graduated scale. In all these cases, the smoothness of motion and the rack-and-pinion control make the microscope stage superior to other knife-edge devices.

J. DEXTER EOFF
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What makes the Tinsley 12" Telescope worth $4850?

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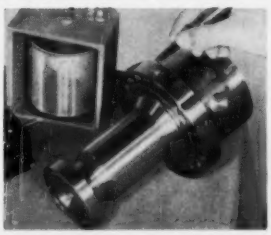
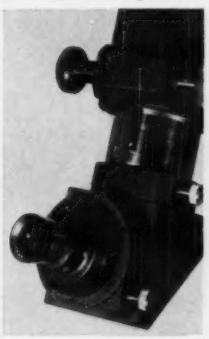


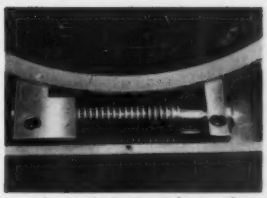
(2) Does it stop and stay where you want it to without quivering? The Tinsley 12-inch does. Its amazing rigidity comes from the positive action clamp mechanism, and its weight. No tremors and blurred images.

(3) The focusing assembly will please even the most exacting astronomers – it combines all the best features and engineering principles. For example: rack-and-pinion assembly (superior, by far, to slow-moving spiral assemblies); positive locking clamp for accuracy. The entire assembly can be removed, and replaced with a camera or spectrograph without loss of alignment. The assembly barrel –as you can see– is ruggedly built. Its 3-inch diameter makes it capable of handling larger-than-average eyepieces and accessories.



(4) In the optical system, Tinsley's skill and experience comes into full play. Tinsley has been making professional telescopes for 30 years, and supplies optics for missiles and rockets. The Cassegrain system of the 12-inch has a primary focal length of 48″, secondary amplification of 4 and total effective focal length of 192″. The telescope is equipped with a finder of 10 power.

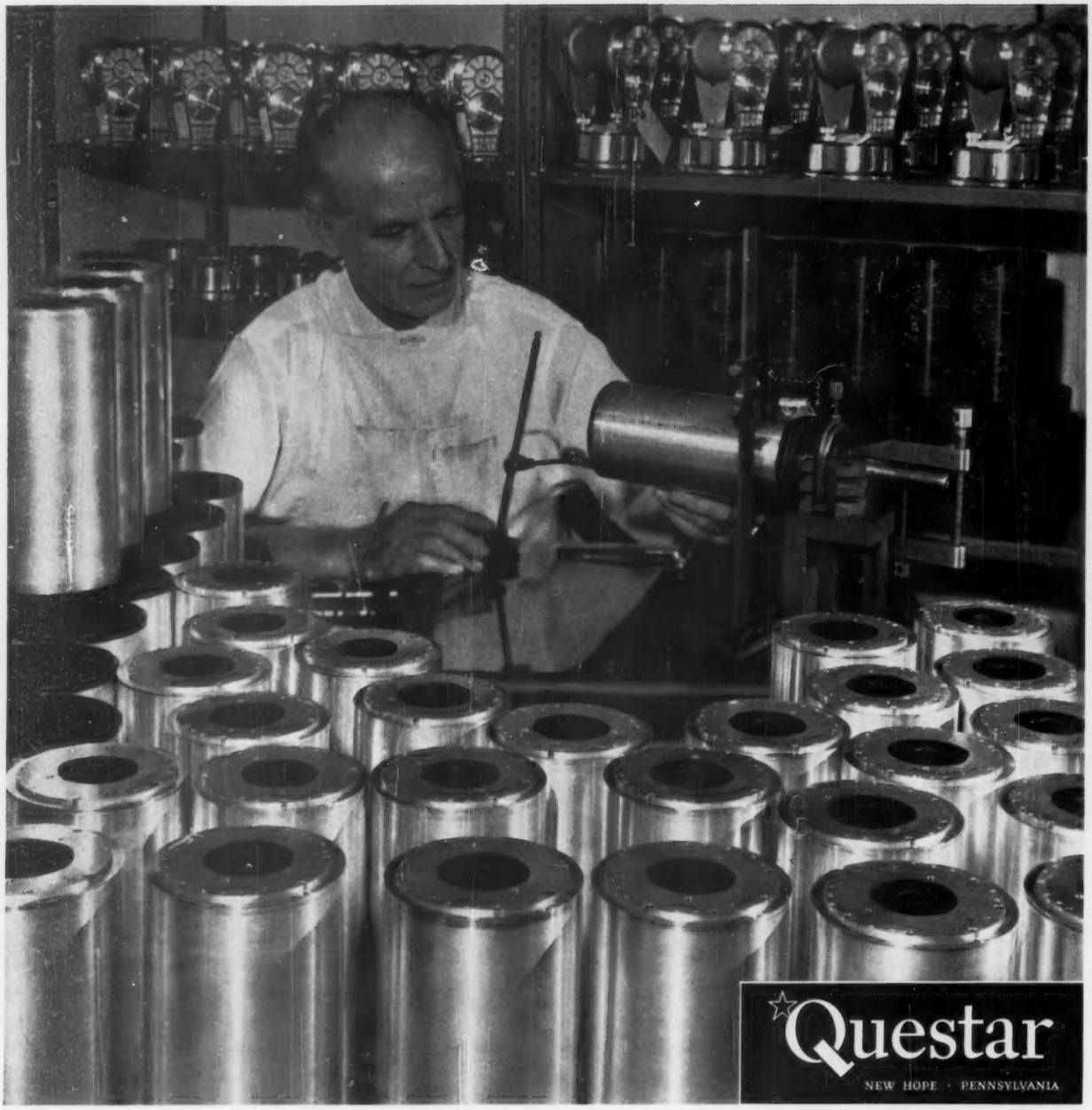
(5) In the motor drive and tracking system there are two Bodine motors in right ascension, one for a precise sidereal rate; the other for fast drive at 5 times the sidereal rate. Worm gears are precision ground. There is manual declination with anti-backlash drive.



These are only the most outstanding features. As a whole, the Tinsley 12-inch is a remarkable telescope, the ultimate instrument for schools and colleges, universities, astronomy clubs and even individuals. (Yes, some of these fine instruments have been purchased by individual amateur astronomers.)

If you can afford the finest, you will want the Tinsley 12-inch telescope.

For a specification folder, write to Tinsley Laboratories, Inc., Department D, 2448 Sixth Street, Berkeley 10, Calif.



Here a group of 50 barrel assemblies is being readied for completion by our Mr. Ernest Arndt. Each barrel consists of 23 parts. The largest piece is an aluminum forging with thin walls and a thick bottom. We send groups of the tall cups or shells to a man named Gerald Fegley, who chose to make parts for Questar in his own shop rather than be superintendent in the die shop of a great die-casting firm. With the engine lathe, Mr. Fegley turns off and discards the forging's entire thick bottom, which exists only to leave enough metal on the inside of the tube to permit him to cut big husky threads. After so doing, he shortens the tube and reduces its outside diameter on the lathe. Mr. Fegley then ships these precisely machined-all-over tubes to a painting specialist, who masks off the large internal threads and the cell seat at the opposite end, then sprays the inside with a newly developed nonreflective paint.

Meanwhile, Mr. Fegley takes a disk of the tempered aluminum alloy 24S-T4, and machines it to fit a heavy ring cut from a tube of similar metal whose wall is .5-inch thick. These two parts, held together by 4 stainless-steel screws, form our barrel's rear closure plate. Stronger than steel, each composite plate is threaded to fit one tube. Both are numbered, and we now have a removable tube, held to its closure by large accurate threads we can trust.

A central hole is prepared and accurately receives a ground stainless-steel tube 4 inches long on which our mirror will slide. The tolerance permitted here is only ±.0001. The matching tube, 3 inches long, fits its mate so well that it will pump air without a lubricant. Thus Questars can focus just as easily at −86° as at room temperature.

The last operation at the Fegley shop presses a lens cell into each barrel. The final cuts are not taken on the lens seat until the entire assembly rotates as a unit on the engine lathe with the inner tube running dead true. The numbered cell is then withdrawn and black anodized; the entire set of matching parts is reassembled, tested for total runout, and delivered in individual cases to us.

Having installed a total of 20 light baffles, Mr. Arndt is here checking one assembly for alignment. It is rare for any to be off-center by more than .0008 inch, a quite permissible amount.

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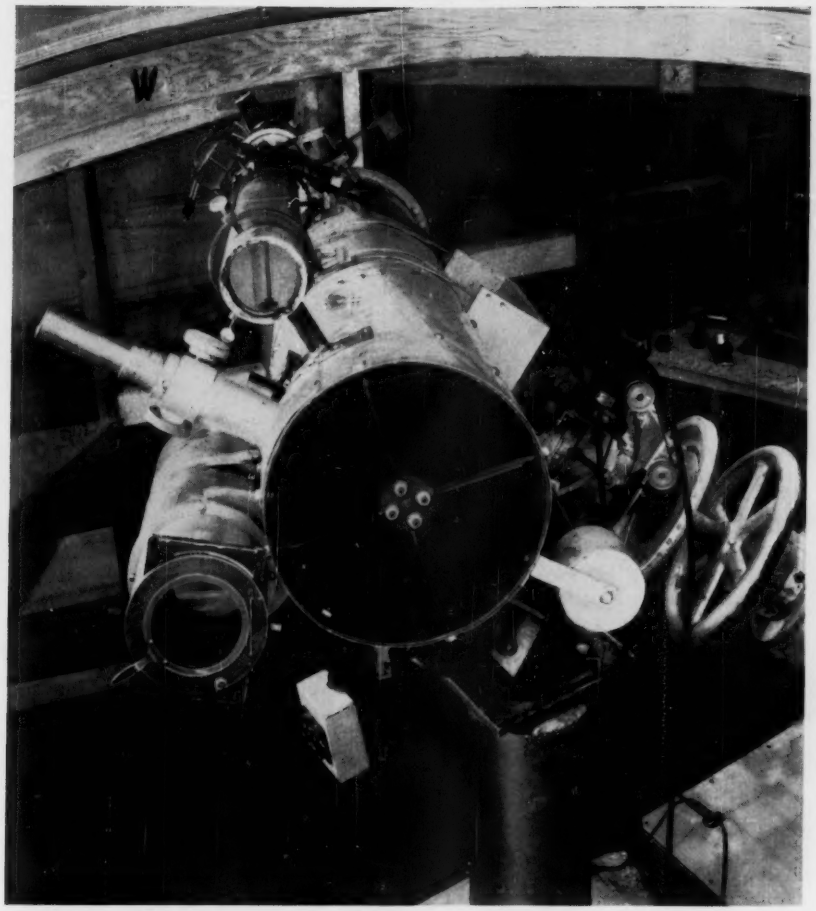

This complex of instruments at the Vista del Cielo Observatory is carried on a heavy mounting and pier. The large spoked wheel at the right, just above the declination counterweight, is used for rapid slewing to any hour angle or declination. Photograph by Matthews Photo Lab.

The Vista del Cielo Observatory in Alberta

ALTHOUGH solar observations are a main activity, the Vista del Cielo Observatory is equipped with a variety of instruments, pictured here. They are housed under a weather-tight 10-foot aluminum-clad dome in a building adjoining my garage, free from the thermal effects of a heated house.

The largest tube in the picture is a 10-inch reflector. Its mirror of 82″ focal length was made by John Mellish and is used for visual observing, especially when I have visitors. To the lower left, below the Newtonian eyepiece of the 10-inch, is a 5-inch refractor used primarily as a sun projector. Of 26″ focal length, its definition is only fair at full aperture, so to minimize chromatic aberration I stop it down to 3″ by means of the iris diaphragm that is seen fully opened in the photograph.

Mounted on top of the reflector is a 3-inch prominence telescope. The objective has a focal length of 42″ and works with a seven-element quartz birefringent monochromator of 1-inch aperture. Maintained at a temperature of 79° Fahrenheit, it effectively isolates the hydrogen-alpha line. For photography of solar prominences I use a Leica 35-mm. camera, which has a special micro-mirror reflex attachment that operates much like a single-lens reflex. Since the reflex housing contains a clear-glass view screen and a magnifier, the camera itself is the eyepiece and never needs to be removed from the

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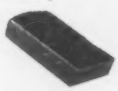

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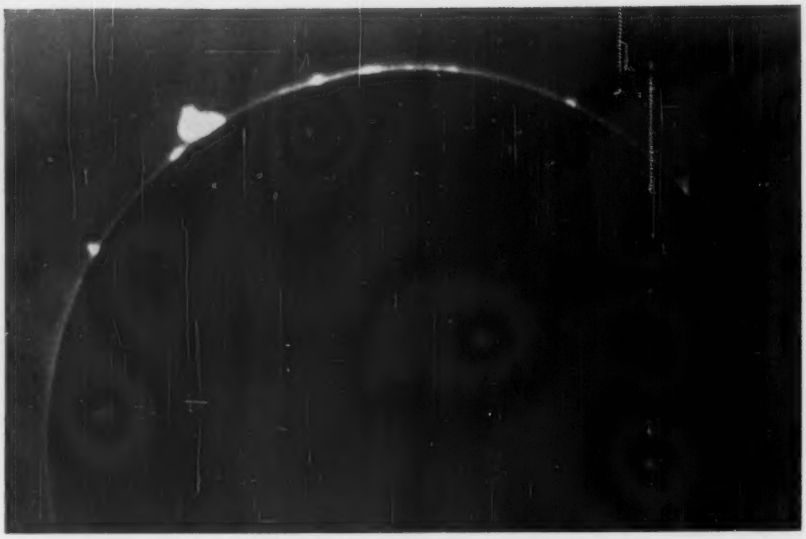

Several prominences on the sun were photographed with the Knox solar telescope on March 12, 1960. Light of the sun's surface is blocked from view by an occulting disk in the instrument, which has a 3-inch objective and a birefringent filter for hydrogen-alpha light. The large prominence at the upper left is about 40,000 miles high.

optical train when I am observing visually. As a further convenience, the reflex housing contains a corrector lens ground to my eyeglass prescription.

The rather small solar image produced by the monochromator can be enlarged in a number of ways: eyepiece projection with and without the camera lens, or that lens alone, with or without extension tubes. Although the monochromator has only a modest aperture, it performs well; but the sun's tiny spicules can be detected only when the seeing is perfect.

The observatory dome rotates on four large casters that are bolted to the supporting walls. The base ring of the assembly is a 3" I-beam bent to the required radius. It serves as an inverted track, and supports the curved ribs of the dome, which were cut with a band saw from 1⅛" plywood panels.

A clock-driven equatorial mounting carries the instrument cluster and is bolted to a concrete pier. The mount was constructed from the rear hubs, bearings, and axle of a Ford F-6 truck. Push-button slow motions are provided for both axes, making observing very convenient. In the picture, the control box is seen hanging beneath the 10-inch reflector's tube.

The monochromator and some of the necessary optics were my own projects, as were the observatory, dome, and all mechanical work connected with the mounting and clock drive.

W. A. KNOX
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The shutter on W. A. Knox's 10-foot observatory dome is divided, the uppermost portion sliding on tracks up and over the top of the building. The lower part hinges outward and downward, but may be left in place for wind protection when the telescope is pointed high in the sky. Photo by Matthews Photo Lab.

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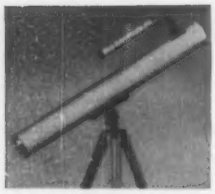

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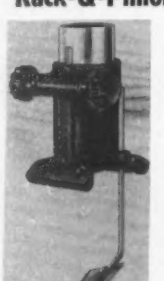

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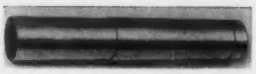

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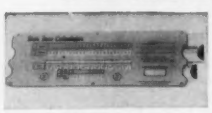

This handy slide rule automatically makes the conversion from star or sidereal time to standard time. Saves the amateur astronomer the time and trouble of calculations. Size: 10⅓″ x 3⅜″; plastic-coated cardboard.

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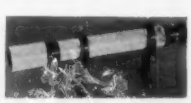

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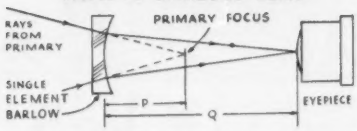

WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.

Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing, with special spacer rings that enable you easily to vary the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Barlow lens is nonachromatic.

Stock #30,200-Y...Mounted Barlow lens....$8.00 ppd.

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These lenses are made for telescopes that have smaller-diameter eyepieces than the standard 1¼" size. Mount one between the eyepiece and objective, and triple your power. Instructions included. Single-element lens, focal length −1-5/16", unmounted.

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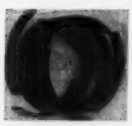

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MORE POWER FROM YOUR JAPANESE TELESCOPE

Mounted Barlow for Japanese Telescopes

By inserting this single-element lens in the eyepiece end of your Japanese telescope, and putting your regular eyepiece in the end of the Barlow tube, you can increase your telescope's power up to three times. Thus, instead of 60x, you will get 120x or 180x. Barlow is mounted in two pieces of telescoping brass tubing each 4" long, satin chrome plated on the outside. Inner diameter of large tube and outer diameter of small tube are 0.965", the standard size for most Japanese telescopes. Measure yours before ordering. 0.965" is approximately 31/32" or 24.5 mm.

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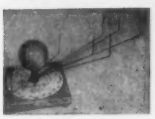

Use to show correct positions of planets each month. Sun is represented by 2½" yellow ball, planets by varicolored 3/16" balls. Planets can be rotated freely around Sun. Distance from Sun to Pluto is 16". Base is 6" square. Directions included.

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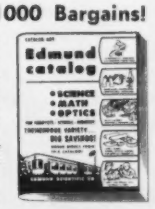

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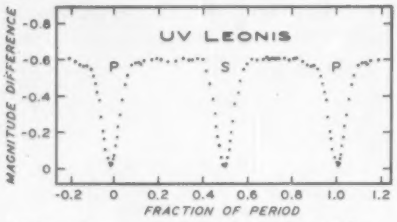
CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

The Rapid Eclipsing Variable UV Leonis

A 3-INCH REFRACTOR is ample equipment for getting acquainted with the unusual behavior of the variable star UV Leonis, located about 7° east of Regulus, at $10^h\ 35^m.7$, +14° 32′ (1950). It is an eclipsing binary, about magnitude 8.5 at maximum, with a period of almost exactly 14.4 hours. Twice in each cycle, the brightness dips 0.6 magnitude in an hour, taking as long to recover to maximum. This pattern is illustrated by P. Wellmann's photoelectric light curve reproduced here.

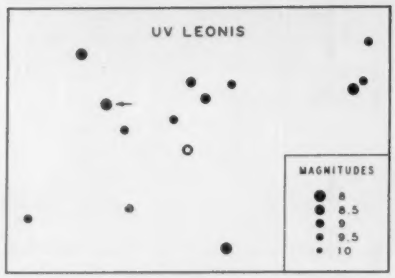


The 0.6-magnitude change in brightness in UV Leonis is illustrated by this light curve. P is for primary minimum, S for secondary. From "Zeitschrift für Astrophysik," 1954.

The short duration of the eclipses of UV Leonis makes the light changes very rapid, and the minima can be timed with high precision visually, or even better photoelectrically. Visual magnitudes are not available for the comparison stars in the chart, but they are actually not necessary for making useful brightness estimates. The following method is good.

When the variable is at maximum, select a star nearby that is very slightly brighter, calling this comparison object A. Choose a second star that is roughly three-quarters of a magnitude fainter, designating it B. Arbitrarily assigning the values 0 and 10 to the brightnesses of A and B, respectively, will establish a light scale, in terms of which the estimated brightness of the variable can be expressed. To determine the time of midminimum of UV Leonis, a plot of its observed scale values against time serves just as well as a plot of real magnitudes.

Because the period of UV Leonis is only seven seconds longer than 0.6 day, five primary minima occur every three days, this month in the following pattern:



The field of UV Leonis, to a scale of ¼ degree per inch. South is at the top. The circle marks the variable.

$11^h.4$ Universal time on March 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, and 31. Other primary minima come at $1^h.8$ and $16^h.2$ UT on March 2, 5, 8, 11, 14, 17, 20, 23, 26, and 29. Also, they take place at $6^h.6$ and $21^h.0$ UT on March 3, 6, 9, 12, 15, 18, 21, 24, 27, and 30. Secondary eclipses can be predicted by adding 7.2 hours to these times.

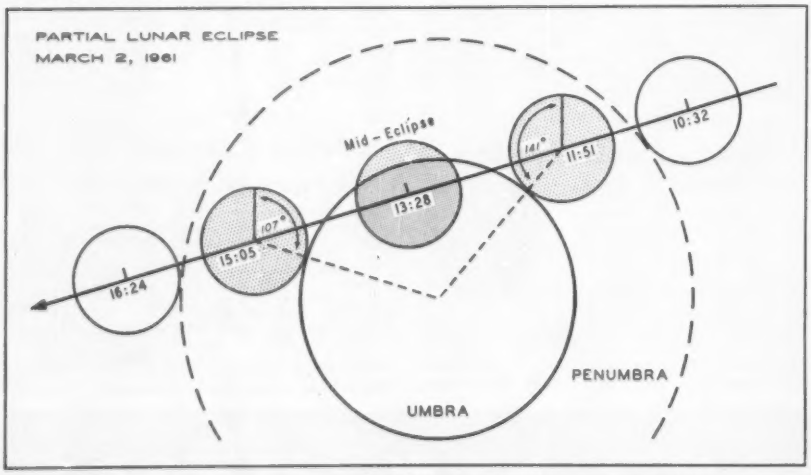
In photoelectric observing, it is necessary to use a comparison star whose color closely matches the variable's. UV Leonis belongs to spectral type *G*0, and hence the *F*8 star HD 91876 has been chosen by most photoelectric observers as the comparison standard. It is identified by a short arrow on the chart.

Moon in Partial Eclipse

IF YOU LIVE in the western part of the United States or Canada, you will be able to witness a partial eclipse of the moon on the morning of Thursday, March 2nd. Mid-eclipse, with 81 per cent of the lunar diameter inside the earth's umbral shadow, is scheduled for 13:28 Universal time (5:28 Pacific standard time).

Nothing of the eclipse will be visible from the Atlantic seaboard. At Cleveland, Ohio, the moon sets only 12 minutes after beginning to enter the umbra at 11:51 UT. Farther westward, this interval is longer and the conditions for viewing the eclipse more favorable. Thus at Denver, Colorado, the moon sets 10 minutes after mid-eclipse, while observers in San Francisco will be able to see all but the last 20 minutes of the umbral phase, which ends at 15:05 UT. At these western stations, sunrise occurs only a few minutes before moonset. Best placed will be amateurs in Hawaii, where all stages of the event will be visible in a dark sky.

Hints on lunar eclipse observing were given on page 227 of the February, 1960, Sky and Telescope. Satisfactory observations of eclipse colorations or timing crater entrances and exits are, however, not feasible in bright twilight or when the moon is very near the horizon.



The path of the moon through the earth's shadow on March 2, 1961.

MINOR PLANET PREDICTIONS

Ausonia, 62, 10.6. February 20, 10:13.3 +12-16. March 2, 10:02.9 +12-48; 12, 9:53.4 +13-13; 22, 9:46.0 +13-26. Opposition on February 20th.

Parthenope, 11, 10.3. March 2, 12:51.3 +0-44; 12, 12:45.1 +1-48; 22, 12:37.2 +2-57. April 1, 12:28.4 +4-05; 11, 12:19.8 +5-04; 21, 12:12.5 +5-48. Opposition on March 29th.

Antigone, 129, 10.1. March 12, 12:55.1 +9-21; 22, 12:49.1 +11-02. April 1, 12:42.0 +12-35; 11, 12:34.7 +13-50; 21, 12:28.3 +14-40. May 1, 12:23.7 +14-58. Opposition on April 1st.

After the asteroid's name are its number and the approximate visual magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

MINIMA OF ALGOL

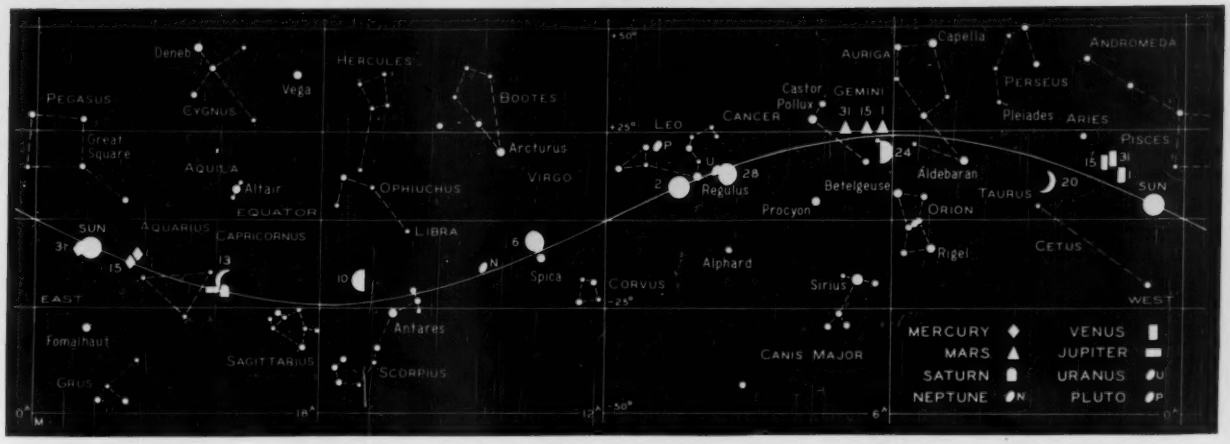
March 2, 4:42; 5, 1:32; 7, 22:21; 10, 19:10; 13, 16:00; 16, 12:49; 19, 9:39; 22, 6:28; 25, 3:18; 28, 0:07; 30, 20:56.

April 2, 17:46; 5, 14:35; 8, 11:24.

These minima predictions for Algol are based on a recent timing by D. Engelkemeir, and an assumed period of 2.8674 days. The times given are geocentric; they can be compared directly with observed times of least brightness.

UNIVERSAL TIME (UT)

TIMES given in Celestial Calendar are Universal time (Greenwich civil time) unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th, and to 10:15 p.m. PST on the 14th.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0^h Universal time on the respective dates.

Mercury, although at greatest western elongation 28° from the sun on March 20th, is poorly placed for observation in mid-northern latitudes. In declination it stands about 12° south of the sun, and will therefore rise only about an hour before sunup during the first half of the month, the light of dawn making this planet seem dimmer than its +0.5 magnitude.

Venus continues to be a prominent object in the western sky, setting about three hours after the sun at midmonth. On March 5th the planet is at greatest brilliancy, magnitude −4.3, and in a telescope appears as a thin crescent 38″ in diameter and 28-per-cent illuminated.

Earth reaches heliocentric longitude 180° at 20:32 Universal time on the 20th. This is the March equinox, spring beginning in the Northern Hemisphere, autumn in the Southern.

The moon undergoes partial eclipse on the 2nd for observers over much of the world, the region of visibility ranging from central North America westward to eastern Europe and Africa, and from the North Pole to Antarctica. At mid-eclipse, 13:28 UT, 81 per cent of the moon's diameter will be immersed in the earth's umbral shadow. (See facing page.)

Mars' brightness diminishes during March from magnitude +0.3 to +0.9 and its diameter from 9″.5 to 7″.3, as the earth steadily moves ahead of the red planet. Mars is in Gemini, and on the 15th crosses the meridian not long after sunset.

Jupiter rises about 2½ hours before the sun in the middle of March. Of magnitude −1.6, the planet shines brightly near the Sagittarius-Capricornus border. Through even a small telescope, its flattened disk is readily discerned, 34″.7 in equatorial diameter and 32″.4 in polar.

Saturn is easily found low in the southeastern sky before sunrise, an object of magnitude +0.9 about 3° west of Jupiter. Viewed telescopically, the ring system appears 35″.6 across on March 15th. The planet's equatorial diameter is 15″.8. A waning crescent moon will be west of Saturn and Jupiter during morning twilight on the 12th, geocentric conjunction with Saturn occurring at 20^h UT that day, with the moon 3° north.

Uranus is in Leo, at right ascension 9^h 39^m.9, declination +14° 47′ (1950 coordinates), on the 15th. It is a 6th-magnitude object crossing the meridian about two hours before local midnight. Telescopically, the planet appears as a small greenish disk, 3″.9 in diameter. The nearly full moon will pass 2° south of Uranus twice in March, on the 1st at 2^h UT, and on the 28th at 7^h.

Neptune, well placed for viewing with small telescopes this month, is in Libra at 14^h 36^m.2, −13° 22′ (1950), on March 15th. The 8th-magnitude planet crosses the meridian three hours after local midnight, and can thus be observed in the southern sky during the late evening and early morning hours. Its disk is 2″.5 in diameter.

WILLIAM H. GLENN

VARIABLE STAR MAXIMA

March 1, RT Cygni, 194048, 7.3; 4, R Leporis, 045514, 6.8; 5, R Hydrae, 132422, 4.5; 7, T Normae, 153654, 7.4; 8, R Corvi, 121418, 7.5; 9, T Centauri, 133633, 5.5; 11, T Sagittarii, 191017, 8.0; 15, R Bootis, 143227, 7.2; 16, R Cancri, 081112, 6.8; 17, R Serpentis, 154615, 6.9; 17, S Gruis, 221948, 7.7; 18, RV Centauri, 133155, 7.7; 25, R Virginis, 123307, 6.9; 27, W Lyrae, 181136, 7.9; 30, R Andromedae, 001838, 7.0.

April 6, T Herculis, 180531, 8.0; 7, S Herculis, 164715, 7.6.

These predictions of variable star maxima are by the AAVSO. Stars are listed only if brighter than magnitude 8.0 at an average maximum. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for their maxima. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted visual magnitude.

MOON PHASES AND DISTANCES

Full moon	March	2, 13:35
Last quarter	March	10, 2:58
New moon	March	16, 18:51
First quarter	March	24, 2:49
Full moon	April	1, 5:48

March	Distance	Diameter
Perigee 14, 18^h	225,300 mi.	32′ 58″
Apogee 26, 15^h	251,600 mi.	29′ 31″
April		
Perigee 11, 8^h	228,500 mi.	32′ 29″

OCCULTATIONS IN MARCH

DURING Tuesday evening, March 21st, the five-day-old moon will pass in front of the Hyades cluster, occulting 11 stars ranging from 1st to 7th magnitude. The 6½-hour series of events will be visible in part from nearly all of the continental United States.

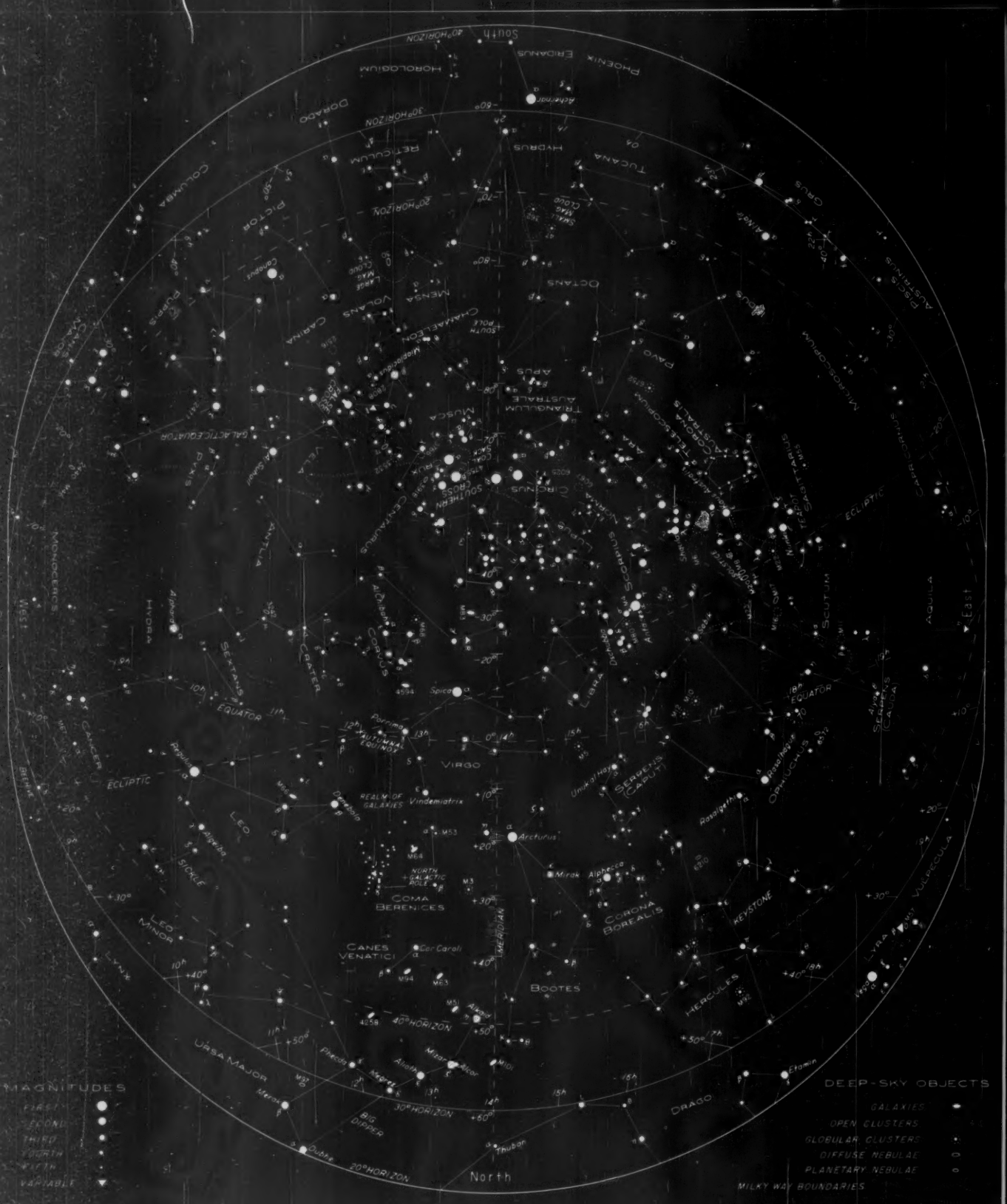
The sequence of occultations begins while the evening sky is still light in New England (Station **A**), where 6th-magnitude 70 Tauri will be hidden by the moon at about 6:30 p.m. Eastern standard time. The bright pair Theta Tauri disappears next, about two hours later for Stations **A** to **F** (Illinois), and 5th-magnitude 264B Tauri an hour later from **A** to **I** (New Mexico-Arizona). Several 6th-magnitude stars are also to pass behind the moon, but for observers in the western part of the country the climax is the occultation of 1st-magnitude Aldebaran.

Detailed predictions for these events are given in the Occultation Supplement of the December, 1960, issue. Aldebaran's immersion at the moon's dark limb will take place at approximately the following times and position angles (measured eastward from the north point):

Disappearance: **G,** Texas, 11:10 p.m. CST, 58°; **H,** Colorado, 10:10 p.m. MST, 31°; **I,** New Mexico-Arizona, 10:05 p.m. MST, 59°; **K,** California, 8:56 p.m. PST, 61°; **L,** Oregon, 8:57 p.m. PST, 36°.

Reappearance: **G,** at horizon; **H,** 10:43, 323°; **I,** 10:58, 296°; **K,** 9:56, 293°; **L,** 9:40, 316°.

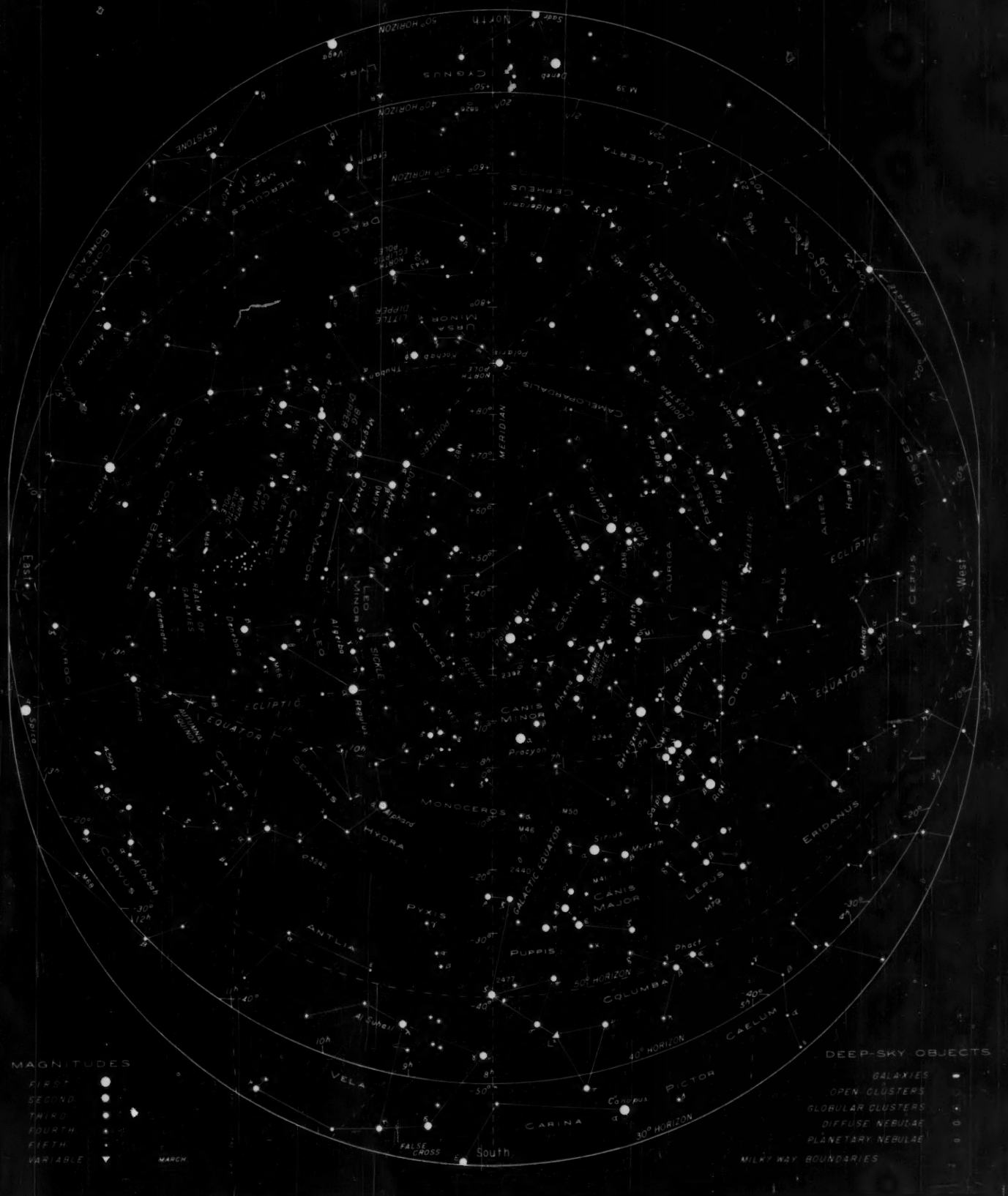
A chart of the Hyades cluster, with the stars labeled by their Occultation Supplement numbers, was published in last year's April issue, page 380.



SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 11 p.m. and 10 p.m., local time, on the 7th and 23rd of May, respectively; also, at 9 p.m. and 8 p.m. on June 7th and 22nd. For other dates, add or subtract ½ hour per week.

In the vicinity of the dark Coal Sack nebulosity, bright stars differing greatly in color can be found. Contrast Alpha Crucis, a blue-white B star, with red Gamma Crucis, of spectral type M. Between these color extremes is the yellow of brilliant Alpha Centauri, type G.



STARS FOR MARCH

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of March, respectively; also at 7 p.m. on April 7th. For other dates, add or subtract ½ hour per week.

Just west of the meridian at chart time is the huge circumpolar constellation Camelopardalis, the Giraffe. This sprawling group is often neglected because it contains no stars brighter than 4th magnitude. It is among the most recent constellations, invented in 1614.

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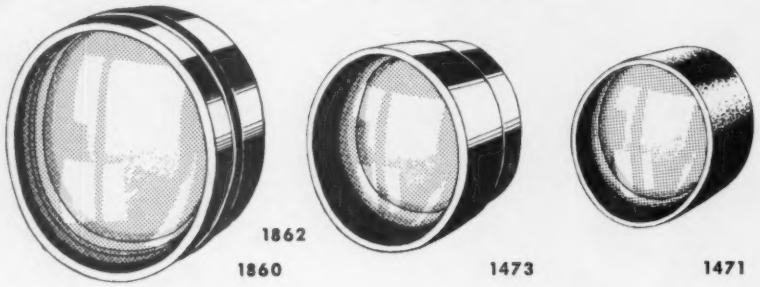

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6" APERTURE f/10 — 60" F. L.	Cat. No. $1861	Unmounted and Coated	$150.00 ppd.
	Cat. No. $1860	Mounted and Coated	175.00 ppd.
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$-955	(3¼")	(34½")	28.00
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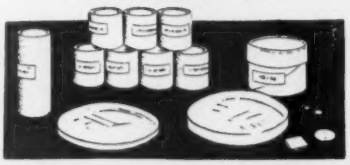
*Not coated.

Astronomical Kits



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$1507	6"	60"	25.00
$2188	6" parabolic	48"	49.50

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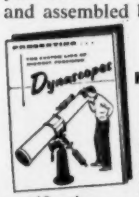

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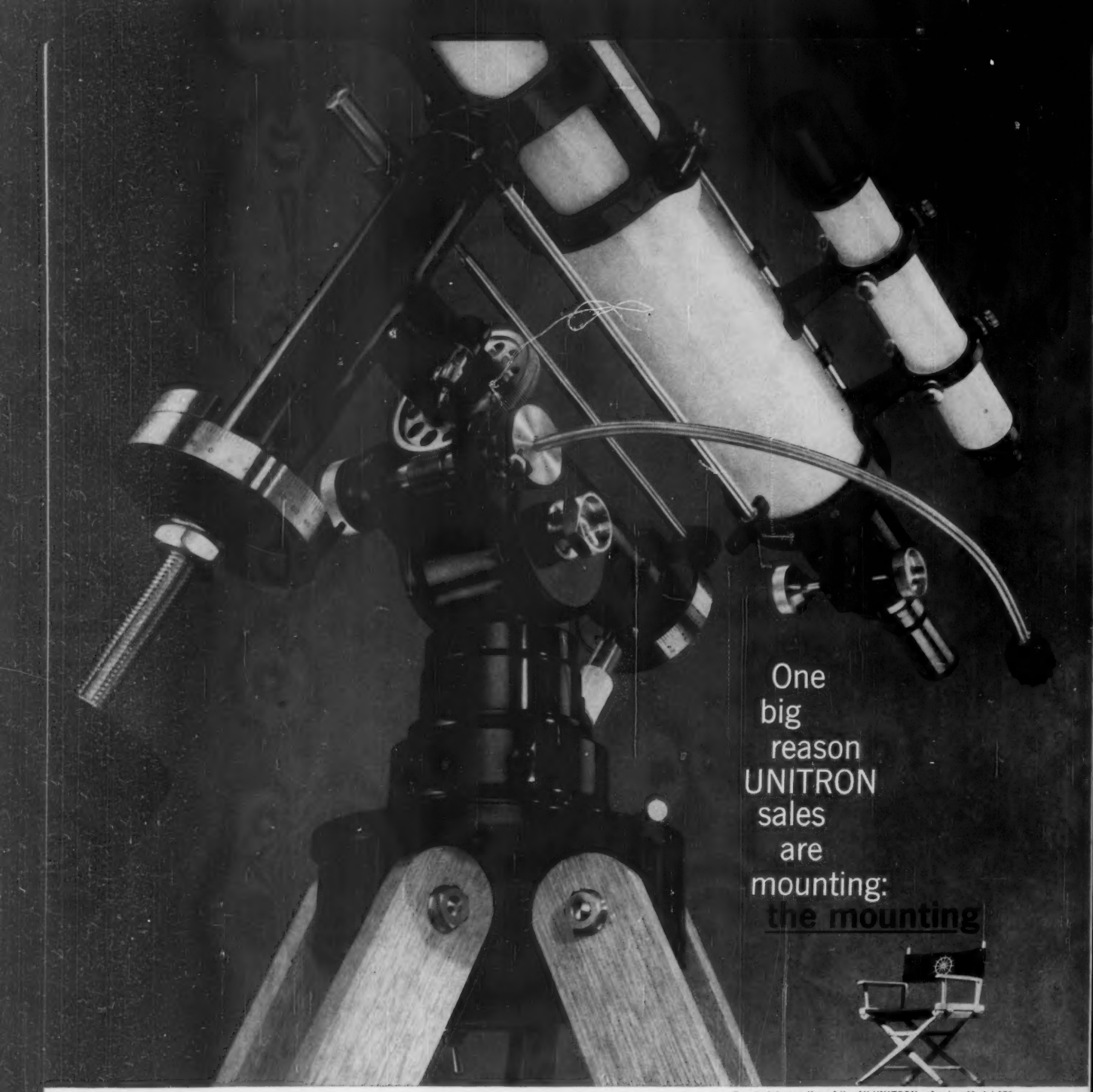


Equatorial mounting of the 4" UNITRON refractor, Model 152.

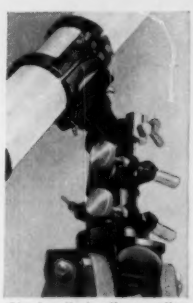
Step up, friend. Sit yourself down at the controls of a UNITRON. Feel the sure response of the slow-motion controls. Note the extra-smooth handling ease. Observe the oversize components, which give UNITRON mountings strength to spare.

If it's an altazimuth model, you have micrometric adjustments for both altitude and azimuth. In the equatorial models, you'll find the mechanism more sophisticated — but the operation is even easier. Here, once you've pinpointed your target, only the single right-ascension control is needed to keep the object centered in the field of view. You'll welcome the added convenience of the new flexible cable extension which brings the right-ascension control within easy reach — a new feature included with all UNITRON equatorials as standard equipment.

Note, too, the precise slow-motion adjustment for declination. Scrutinize the precision gears designed to deliver generations of velvet-smooth performance. Examine the large easy-reading setting circles and verniers provided on the 3" and larger models.

(What you won't see is the instrument's complex of inner workings — a blend of the arts of the artillery engineer and the Swiss watchmaker that gives you an instrument whose response will be obedient to the slightest touch of your fingers.)

And — while you're at it — don't forget to look through the refractor. UNITRON's optical excellence is the other big reason UNITRON sales are mounting.



Sturdy altazimuth mounting with slow-motion controls as well as rapid motions for altitude and azimuth.

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SEE PAGES 170 AND 171 FOR MORE ABOUT UNITRON.